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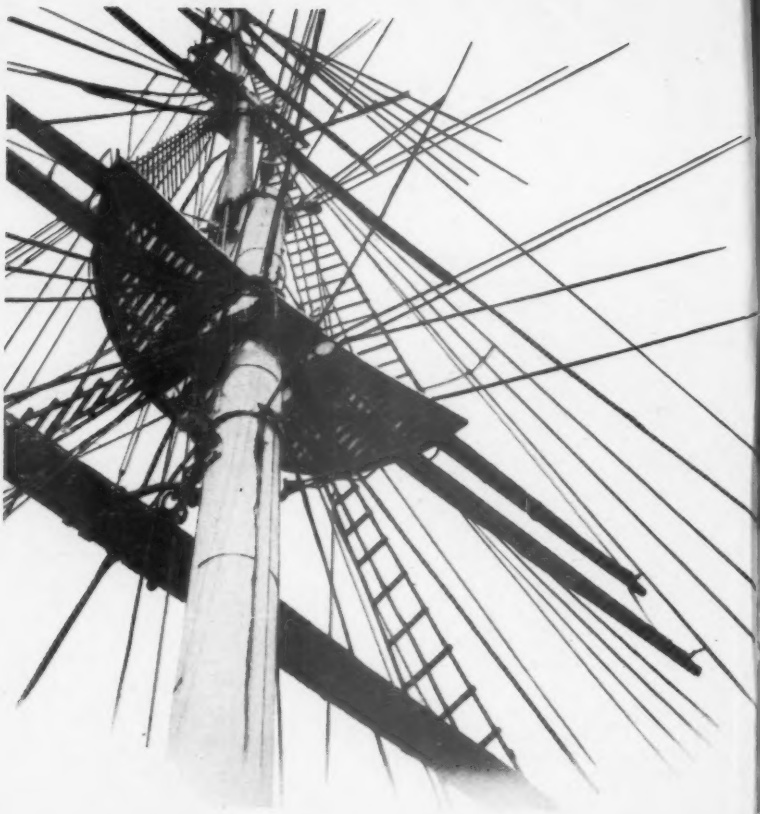

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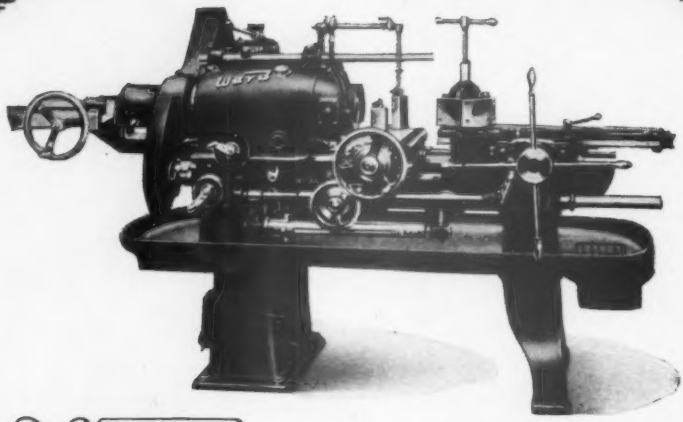

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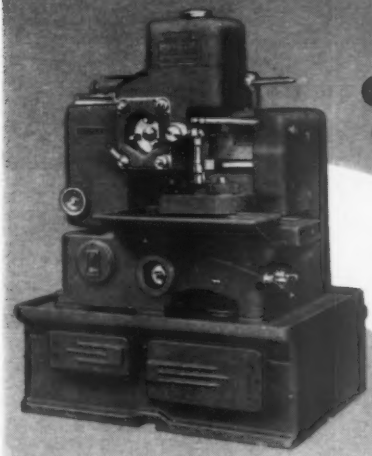

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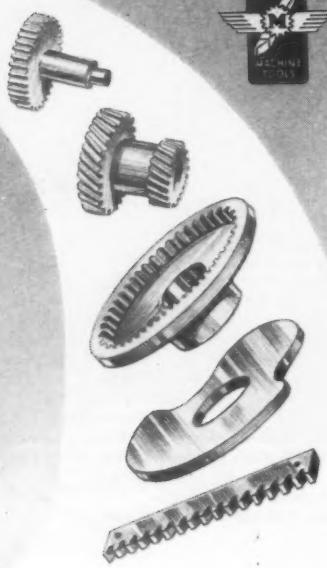

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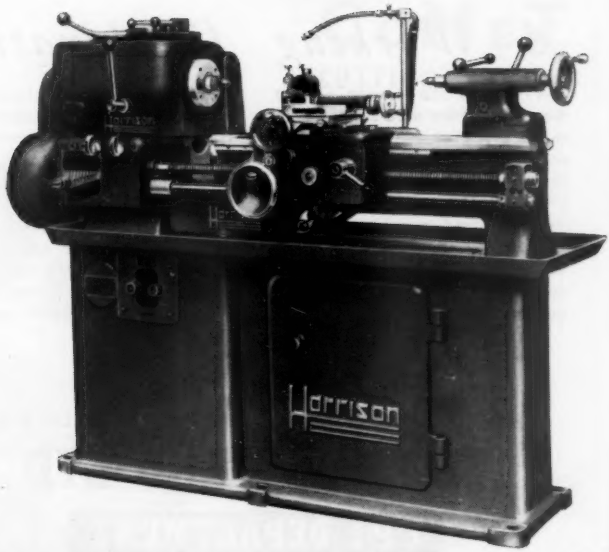

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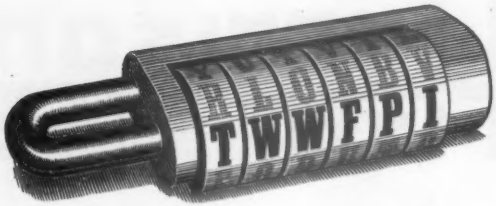

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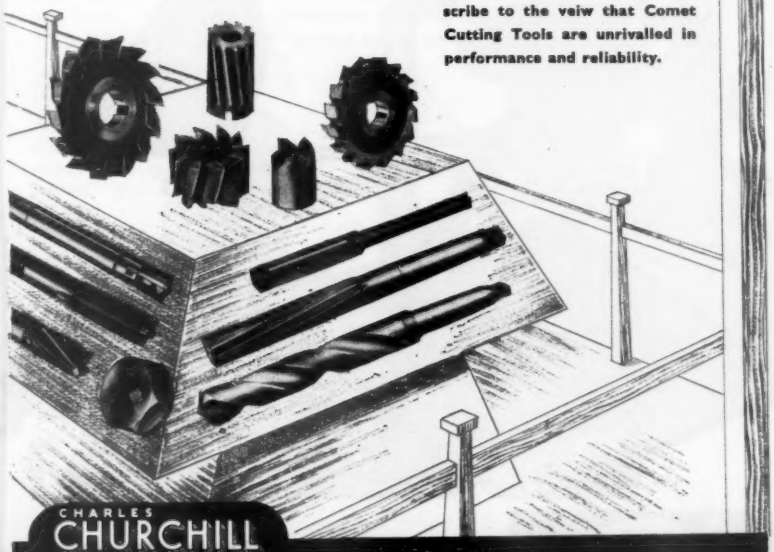

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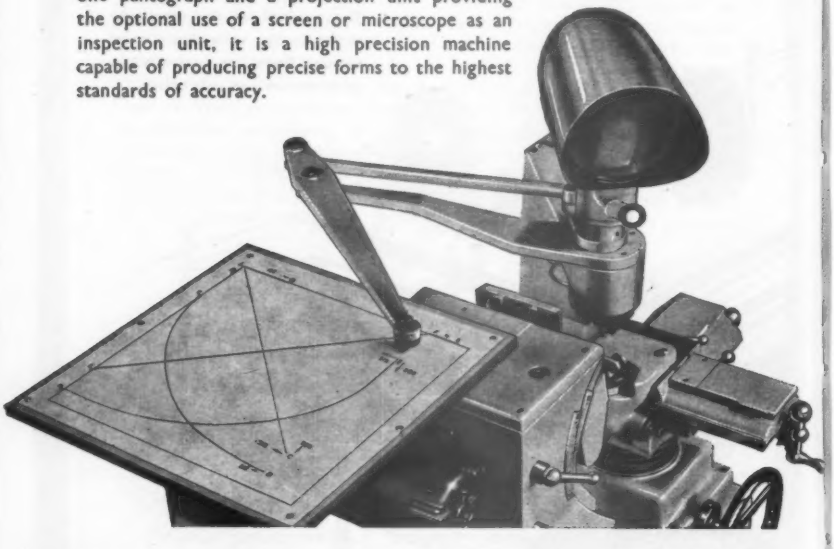

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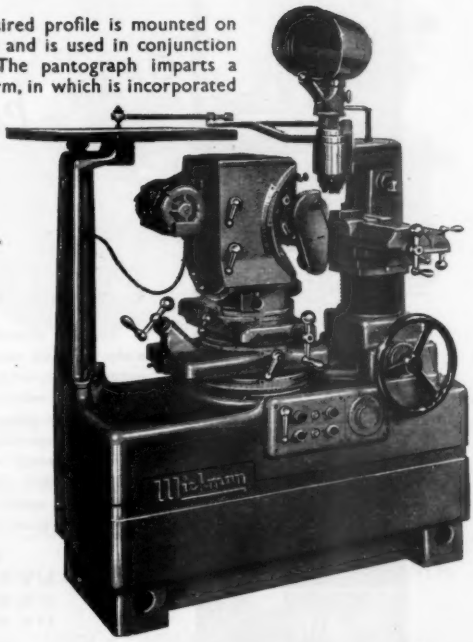

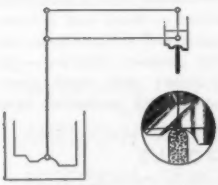

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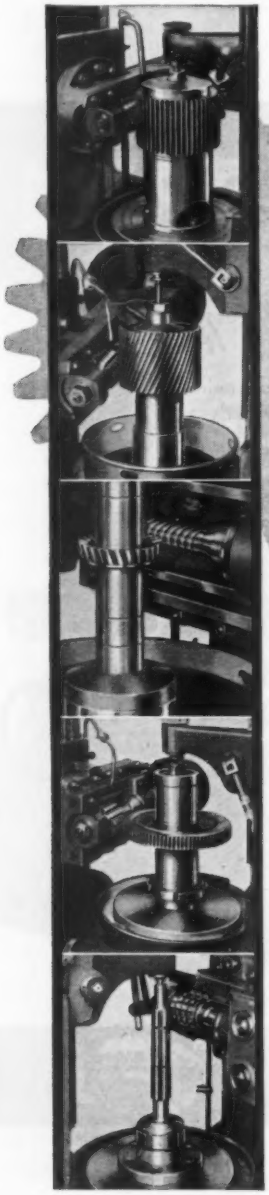

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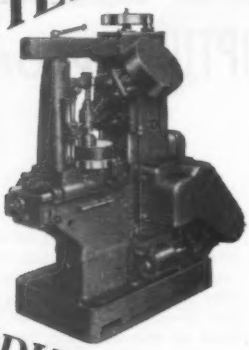

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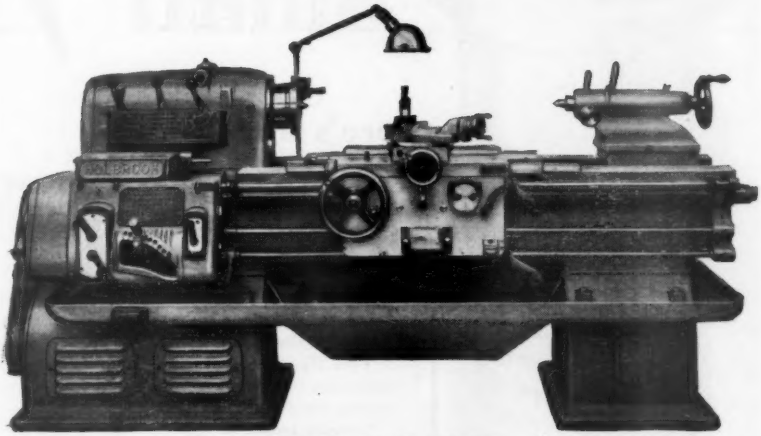

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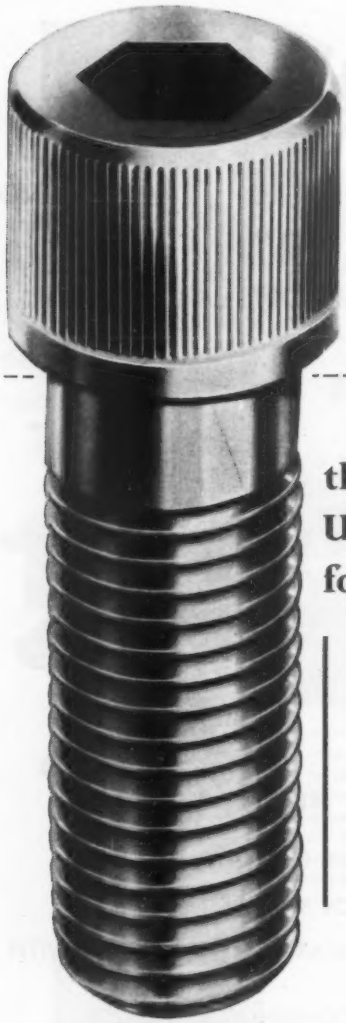

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West Wales Section	H. P. Sanderson, I.C.I. Ltd. (Metals Division), Waunarlwydd, Nr. Swansea.
Wolverhampton	W. J. Marshall, Central View, Norton-in-Hales, Market Drayton, Shropshire.
Yorkshire	J. L. Townend, 26, Moor Allerton Drive, Street Lane, Leeds, 7.

CORRESPONDING MEMBER IN THE MIDDLE EAST

J. Merkine, 45, Arlozoroff Street, Ramat-Gan, Israel.

GRADUATE SECTION HONORARY SECRETARIES

Birmingham	W. Silberbach, 44, Linwood Road, Handsworth, Birmingham, 21.
Coventry	L. Rutter, 1, The Countess's Croft, Cheylesmore, Coventry.
Halifax	J. Taylor, 32, Hill Top Road, Paddock, Huddersfield.
Liverpool	C. W. Haigh, 2 Richmond Avenue, Haydock, Lancs.
London	F. Rutter, 67, Sefton Avenue, Mill Hill. London, N.W.7.
Luton	C. S. Brewer, 44, Beverley Road, Luton, Beds.
Manchester	G. H. Armes, 14, Fairmile Drive, East Didsbury, Manchester, 20.
North Eastern	A. Gilmore, 19, Lynwood Avenue, Blaydon-on-Tyne, Co. Durham.
Sheffield	G. Shaw, C. & J. Hampton, Ltd., Sheffield, 2.
Western	C. H. Spearing, Severn View, Easter Compton, Nr. Bristol.
Wolverhampton	W. L. Pace, " Linden ", 10, Ezekiel Lane, Short Heath Willenhall, Staffs.
Yorkshire	G. Horner, 9, Brougham Street, Skipton.

THE JOURNAL OF

THE INSTITUTION OF PRODUCTION ENGINEERS

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THE THIRD ANNUAL SUMMER SCHOOL OF PRODUCTION ENGINEERING

ASHORNE HILL, Near WARWICK

27th August—31st August, 1952

THE Institution held its third Annual Summer School at Ashorne Hill, a country house near Warwick owned by the British Iron & Steel Corporation Ltd. Ashorne Hill, which stands in beautiful grounds in the heart of the Warwickshire countryside, proved to be an ideal centre for a Summer School. The domestic arrangements were excellent, the staff charming and efficient, and the conference facilities unequalled.

Those who attended the School particularly appreciated the contribution of Sir Cecil Weir, The President, who was in residence for the whole period. He left late on the night of Saturday, 30th August to fly to Luxemburg the next day, in order to take up his duties as Head of the United Kingdom Delegation to the High Authority of the European Coal and Steel Community.

The theme for the School was " The Processes of Production," and after the opening lecture on their study and application, it was developed through two sections. The Education and Training Section considered the closely related subjects of the study of, and training in, production processes, whilst the Industrial Application Section devoted its attention to the human and machine problems involved in planning and controlling the processes.

Lectures were delivered simultaneously to the two sections, after which members discussed the lecture subjects in groups formed within each section. Both sections then assembled together, under the chairmanship of Mr. G. R. Pryor, the Vice-Chairman of Council, to hear the reports of the groups and the final replies of the lecturers.

After dinner on the Wednesday, Friday and Saturday evenings, addresses were given by the President; Mr. Edgar P. Harries a prominent retired trades union official, and Mr. E. F. Schumacher, the Chief Economist to the National Coal Board.

Members were particularly fortunate on the Thursday afternoon in having anopportunity of visiting the works in Coventry of Alfred Herbert Ltd., and of being entertained to tea there by Sir Alfred Herbert, who was himself a President of the Institution from 1927-1929. After an early supper a large party then went to Stratford Memorial Theatre and enjoyed a superb performance of " The Tempest."

This photograph, taken during the visit to the Coventry Works of Alfred Herbert, Ltd., shows *(l. to r.)* Mr. P. O. Fabiyi (Associate), Mr. W. F. S. Woodford (Institution Secretary), Sir Cecil Weir (President of the Institution), and *(extreme r.)* Mr. R. C. Fenton (Member), District Manager, Alfred Herbert Ltd.'s Birmingham office.

Opening Address by the President, Sir Cecil Weir, K.C.M.G., K.B.E., M.C., D.L.

After expressing the pleasure which it gave him to preside over the Summer School and to become better acquainted with colleagues in the Institution and other friends, the President paid tribute to the devoted and effective work of his predecessor, General Appleyard, and the Chairman for the past two years, Mr. Puckey.

Production engineering, he continued, might be said to be the widest of all the production sciences—it might be possible for some people to say where it began and ended, but he was not one of those people. He was glad to see that the lessons learned from the investigations of the Anglo-American Council of Productivity teams were being recognised, for it was only by strength of resolve and purpose that we could meet the pressing problems of rearmament and at the same time maintain and increase our export trade, on which we were so dependent for survival and an improvement in our standard of living.

Finally, turning to the future, Sir Cecil made a plea for new expansionist ideas in the financial and economic fields so that the fruits of industrial and agricultural progress might become readily available to all those who required them.

On behalf of the School, Mr. H. Burke, the Chairman of Council, thanked the President for his most inspiring address.

After a survey of the School's programme by the Education Officer, Mr. T. B. Worth, the first lecture was given on the morning of Thursday, 28th August, by Mr. M. Seaman, to both sections of the School.

The Study and Application of the Processes of Production by M. Seaman, M.Sc. (Director and General Manager of the British Oxygen Engineering Co., Ltd.).

After referring to the lead which had been given by the President in his broad approach to the wide field of application of production engineering techniques, Mr. Seaman considered first the social responsibilities for production and the importance of full utilisation of the human, material and process resources.

He illustrated in a comparative survey the time, motion and material processes and related them to the human factors and the economic controls which were applied. He then considered, first on a unit and later on a national basis, the financial and organizational administrative powers.

The professional responsibility for an orthodox approach which did not restrain initiative but left clear the line of responsibility was illustrated in a diagrammatic form, from a Foundry Case study.

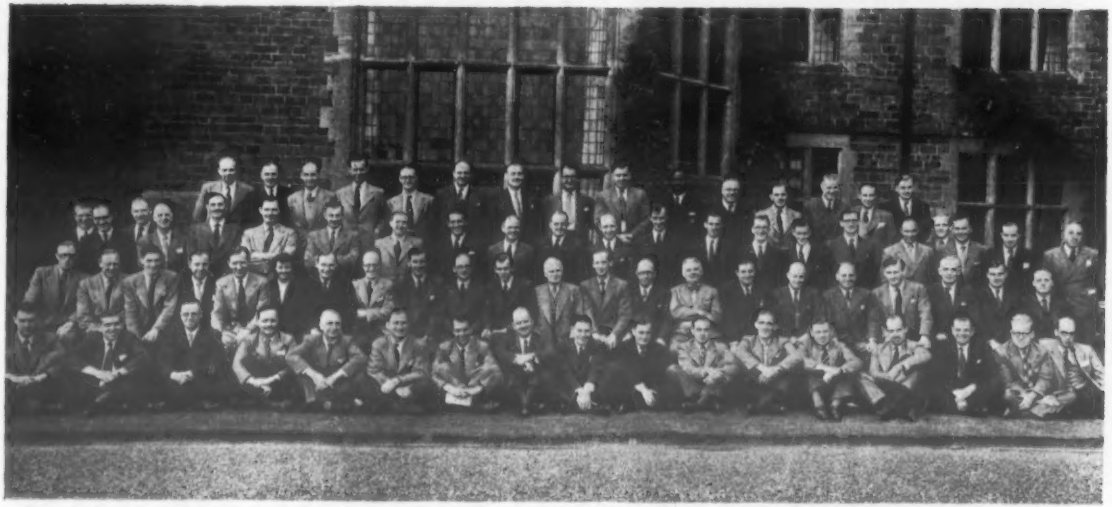
Finally Mr. Seaman considered problems involved in the education of production engineers and suggested radical changes in the traditional methods, which involved little if any production engineering bias at a time when students should be preparing themselves for careers which, in the majority of cases, required a very thorough knowledge of the fundamentals and applications of production engineering techniques.

After the first lecture the School split into its two sections, lectures being given by Professor J. V. Connolly and Mr. E. M. Price to the Education and Training Section, and by Mr. B. E. Stokes and Mr. B. G. L. Jackman to the Industrial Application Section.

The Study of Production Processes by Professor J. V. Connolly, B.E. (Sydney). (Head of Dept. of Aircraft Economics and Production, the College of Aeronautics.)

Professor Connolly demonstrated, by means of a film specially taken for the lecture, the type of equipment required for a study at advanced level of such subjects as metallurgy and heat treatment, forging, stamping, pressing and stretch forming, machining, metrology, work study, and the organization and layout of the factory unit.

THIRD ANNUAL SUMMER SCHOOL, 1952



Back Row.

C. Greenhalgh, W. H. Brayshaw, S. Crawford, E. F. Yoemans, C. J. Swain, S. A. J. Parsons, T. G. Woodward, W. J. S. Hunter, G. A. D. Coghlan, P. O. Fabiyi, L. E. Glover, R. Dent, A. P. Peat, J. Woodriff, R. Hayman.

Third Row.

G. S. Bosworth, A. Hambly, J. Cherry, T. A. Wolstenholme, S. C. Elliott, Major L. N. Morris, Lt.-Col. M. M. Borley, I. W. Mudge, D. Oswin, D. H. Andrews, J. C. Barker, C. Ellis, R. L. Crow, W. H. Hunt, A. Hines, H. C. Eales, R. E. Hyde, W. G. Thomas, D. M. Portman, F. A. Clements, M. Rowland, H. C. Town.

Second Row.

A. C. Hughes, L. H. Hancock, J. E. Taylor, E. Beresford, G. E. Knight, N. Dancer, W. F. S. Woodford, T. B. Worth, B. E. Stokes, E. M. Price, E. F. Schumacher, Sir Cecil Weir, P. A. M. Gell, L. Jackman, G. R. Pryor, B. G. L. Jackman E. P. Edwards, H. Teasdale, D. J. Norfolk, J. J. Peters, W. N. Aspinall, N. F. Bratt.

Front Row.

J. Pye, N. P. Hughes, K. H. Matthews, G. E. Dodd, Major P. L. Fennessey, Lt.-Col. T. C. Lowrie, J. B. Scott, J. F. A. Radford, A. McWilliams, L. Miller, P. W. Wilkes, H. W. Peake, W. F. Smithers, H. P. A. Moser, F. Johnson, G. Sutton, P. F. Dyer.

He then considered the mental equipment and prior training needed before an advanced study of such subjects could be undertaken. Finally particular instances were given of studies carried out in each field, such as the effect of electrolytic polishing on fatigue; the development of plastic tools; the development of cutting; the measurement of turbine blades by a linear air gap type of instrument; the development of various work study techniques; and the build-up in aircraft factories.

Practice in Production Processes by E. M. Price, M.A. (Manager, Rugby Works, The English Electric Co., Ltd.).

Mr. Price considered that in the two main divisions or stages of pre-manufacturing and manufacturing, the three broad functions of the production engineer were planning, organizing and " trouble-shooting." From this basis he proceeded to analyze the requirements of the production engineer.

There were in general three grades of recruits—the craft apprentice, the student apprentice and the graduate apprentice—and Mr. Price discussed in some detail the type of training required for each of these three types.

Finally he commented on the relationship which should exist between training facilities at the Works and in the College and University and concluded with a survey of some of the special problems confronted in the training of Production Engineers.

Planning and Controlling the Processes of Production (Machine Aspects), by B. E. Stokes (Schofield Scholar) of Joseph Lucas Ltd.

Mr. Stokes set out the three main stages which are involved in production planning and control as (i) Management policy planning, (ii) Providing the tools for the Job and (iii) Factory or shop floor planning.

Management policy provided, he said, the mainspring for successful operation and he particularly stressed the importance of a clear statement of objectives and a sound organisation to achieve them. The next stage, providing the tools for the Job, comprised two main tasks—the provision of the most efficient processes and services and their availability on time. Problems of factory planning and control were then discussed and illustrated by examples.

In conclusion Mr. Stokes stressed the need for production planning and control to be considered as a continuous process throughout its three interdependent stages.

Front Row.
J. Pye, N. P. Hughes, K. H. Matthews, G. E. Dodd, Major P. L. Fennessey, Lt.-Col. T. C. Lourie, J. B. Scott, J. F. A. Radford, A. McWilliams, L. Miller, P. W. Wilkes, H. W. Peake, W. F. Smithers, H. P. A. Moser, F. Johnson, G. Sutton, P. F. Dyer.

Planning and Controlling the Processes of Production (Human Factors) by B. G. L. Jackman (Works Director, British Heat-Resisting Glass Co., Ltd.).

Mr. Jackman enumerated some of the principles involved in the planning and controlling of the execution of a project and followed by discussing the administrative, technical and educational problems which arose from the production process.

On the administrative side he considered some of the problems inherent in shift-working, including shift handover, equipment, time-keeping and attendance, and labour relations. Technical problems and their effect on human relations were illustrated by examples from the glass industry.

Finally, after dealing with such educational matters as training for interchangeability and the relationship between training within industry and college training, Mr. Jackman concluded by listing the major factors which in his opinion achieved satisfactory control from the human angle.

The Addresses :

The Producer and the Customer by Edgar P. Harries.

Mr. Harries, in a most stimulating address, considered that the basic interests of the producer and the customer were identical, since all were consumers and most consumers were also producers. He defined their community of interest as being the production of quality articles at the least cost under the best possible conditions.

This was an ideal which could be achieved if the conservatism of both management and workers could be overcome, and if some of the restrictive practices and other causes of frustration could be removed. Mr. Harries illustrated some of these difficulties with examples taken from his own experience and concluded by advocating a concentrated effort by both sides of industry to create a real understanding of each other's difficulties. If that could be brought about, he said, it would be possible to prove that a factory really was an experiment in co-operative living.

Production for Survival by E. F. Schumacher (Chief Economist to the National Coal Board).

Mr. Schumacher outlined the United Kingdom's historic trading policy of exchanging with the rest of the world manufactured articles for foodstuffs and raw materials. He then pointed to the weaknesses in such a policy in a world in which foodstuffs and raw materials were becoming scarcer and more expensive in relation to manufactured goods, whilst countries which had always been accepted as markets for goods were to an increasing extent themselves becoming industrialised.

Mr. Schumacher suggested firstly that Britain should develop her own food and raw material potential in a vigorous manner, secondly that she should concentrate more on making raw materials go further, and thirdly that she should export in the main goods the value of which lay in the product of brainpower and skill rather than of imported or exportable raw materials.

In this way, the country's need for essential imports could be reduced and paid for by the export only of those products or services in the provision of which we possessed clear-cut advantages.

Finally, Mr. Schumacher called for a conscious policy from all of " Production for Survival."

The President concluded the proceedings and in doing so he expressed the thanks of all the members of the School to Colonel and Mrs. Alexander and their staff for the comfort and efficiency of the arrangements which had been made for them at Ashorne Hill.

The full proceedings of the Summer School will be published in due course and copies sent free of charge to all those who attended the school.

Members who did not attend the school may obtain copies price 2/6d. on application to the Head Office.

INSTITUTION NOTES

October, 1952

The George Bray Memorial Award

At the Annual Dinner of the Yorkshire Section held at the Hotel Metropole, Leeds, on 26th April, under the chairmanship of Mr. F. T. Nurrish, M.B.E., a very pleasing ceremony took place when Lt.-Col. Clifford Bray, T.D., Chairman and Joint Managing Director of Geo. Bray & Co. Ltd., presented to the Institution a cheque for £500, to be invested so that the interest every year will enable the Institution to make an annual award in memory of the late Col. George Bray.

Col. George Bray

Lt.-Col. Clifford Bray spoke of the very warm regard which his uncle, Col. George Bray, had had for the Institution, and he and his co-directors had decided to make this donation in order to perpetuate Col. Bray's regard for the Institution.

In accepting the cheque on behalf of the Institution the President, Major-General K. C. Appleyard, C.B.E., expressed his deep appreciation of the kindness of the Directors of Geo. Bray & Co. Ltd. in making this generous donation. It would enable the Institution, he said, to make an award every year for some outstanding act in production engineering and, at the same time, to pay permanent tribute to the late Col. George Bray, who had done so much to foster the growth of the Institution, not only in Yorkshire, but wherever his influence was felt.

NEWS OF MEMBERS

Mr. A. W. Black, Associate, has taken up an appointment as Production Manager with Majolica Lamps, Ltd., Pinetown, South Africa.

Mr. H. G. Bottomley, Associate Member, has now taken up an appointment in charge of Development at Douglas Fraser & Sons Ltd., Arbroath.

Mr. W. R. Childs, Associate Member, is now Works Manager of Monitor Engineering & Oil Appliances, Ltd., Birmingham.

Mr. C. Evans, Associate Member, has been appointed Lecturer in Production Engineering at the Brooklands Technical College, Weybridge.

Mr. S. G. Lane, Associate Member, is now in business on his own account as a Welding Engineer, and is taking over premises near Sevenoaks, Kent.

Mr. J. G. Lloyd, Associate Member, has been transferred to Leeds where he has been appointed Assistant to the Managing Director, and a Special Director of Geo. Mann & Co. Ltd., Hunslet, Leeds, a subsidiary of Vickers, Ltd.

Mr. W. D. Opher, Member, Works Superintendent of Vickers-Armstrongs, Ltd., Crayford, since 1948, was recently appointed to the Board.

Mr. W. F. Pailing, Member, has jointed E.N.V. Engineering Co. Ltd., London, as Works Director. He has relinquished his executive post with the Maudslay Motor Co. Ltd., of Coventry and Alcester, but remains on the Board of Directors.

Mr. C. Timms, Member, is now Senior Principal Scientific Officer, Head of Mechanisms and Metrology Division, Mechanical Engineering Research Laboratory, East Kilbride.

Mr. T. C. Winmill, Associate Member, until recently Chief Production Engineer of Cox & Co. (Watford) Ltd., has now been appointed Chief of Organisation and Methods Department of that firm.

Mr. W. Elliott, Graduate, is now a Leading Draughtsman with the Ministry of Supply, Chorley, Lancs.

Mr. R. A. Hunter, Graduate, is now Gas Turbine Development Engineer with C. A. Parsons, Ltd., Newcastle-upon-Tyne.

Mr. D. J. Little, Graduate, is now Service Manager for The Cuffley Motor Company, Cuffley, Herts.

Mr. J. G. McDonald, Student, has been successful in obtaining a scholarship for one year's study of Business Management and Administration in the U.S.A. He will take up a place in the Graduate School of Business Administration at Harvard.

Visitors from Abroad

Many members, to whom he is well-known, will be interested to hear that Mr. C. A. Gladman, Member, of the Metrology Division, National Standards Laboratory, Sydney, is now visiting the United Kingdom.

Mr. Gladman, who is at present working with Mr. N. A. Esserman, Chief of the Division of Metrology, to establish facilities within the Commonwealth Scientific and Industrial

Research Organisation for production engineering research in Australia, intends to visit research establishments in Great Britain, Europe, and the U.S.A.

He will also attend the Instruments and Measurements Conference in Stockholm, and the General Meeting of the International Institution for Production Engineering Research, in Louvain.

Another member of the Sydney Section, Mr. Peter Cottrell, Graduate, is visiting the United Kingdom on a Kolling Scholarship from the Sydney University. This enables him to take a one year Post-Graduate Course in Production Engineering at the University of Birmingham.

Mr. Cottrell, who is employed at the Small Arms Factory, Lithgow, also hopes to obtain information on the running of Graduate Sections of the Institution in this country.

Lincoln Members' Retirement

An event of particular interest to the Lincoln Section took place recently with the retirement of Mr. T. McGlashan, Member, and Mr. F. J. Taylor, Associate Member, Works Manager and Shop Superintendent respectively of Ruston & Hornsby, Ltd., Boultham Works.

Mr. McGlashan, who has been with the firm for 36 years, has been attached to the Lincoln Section since it was formed in 1943, and has made a notable contribution to the building up of the Section. He was its Chairman from 1948 to 1950, and members of the Section Committee have made a presentation to Mr. McGlashan in recognition of his services. He is also a Past-President of the Grantham Engineering Society.

Mr. Taylor, who has also been attached to the Lincoln Section since its formation, has received a special service medal from Ruston & Hornsby in recognition of the fact that he has spent 50 years with the firm, which he joined in 1902.

The Institution offers warmest good wishes to Mr. McGlashan and Mr. Taylor for a long and happy retirement.

British Standards

The following Standards have recently been issued and may be obtained, post free, at the prices stated, from the British Standards Institution, 24-28, Victoria Street, Westminster, London, S.W.1 :—

B.S. 678 : 1952 Carboys and Carboy Hampers (3/6d)

B.S. 1869 : 1952 Crash helmets (2/6d)

B.S. 1874 : 1952 Sizes for packages for Frozen Food (2/-)

HAZLETON MEMORIAL LIBRARY

It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when borrowing books.

ABSTRACTS

621.54 COMPRESSED AIR

" Compressed Air in Mining and Industry " edited by Sydney H. North. *London, Pitman.* 1951. 170 *pages. Illustrated. Diagrams.* 18/-.

The chapters in this book can be sub-divided under two main headings, namely: " pneumatic plant " and " efficient operation of pneumatic plant." In the latter category, such subjects as the " elimination of moisture, oil, dust and heat," " care and treatment of pneumatic tools " and " lubrication " are all fully covered. The remaining chapters are sub-divided again between descriptions of the manifold uses of compressed air in particular fields (such as " in Mines and Quarries," " in Industry " and " in Constructional and Public Works "), and descriptions of individual items of compressed air equipment (" air compressor types in relation to requirements," " pneumatic conveying " " portable compressors," " pneumatic tools," and " pneumatic appliances ").

The references to the use of compressed air in the workshop are mainly confined to brief mention of pneumatic chucks, but there are general notes on the handling of compressed air and its associated appliances.

658.23 FACTORY LAYOUT: PLANNING

" Plant Layout: Developing and Improving Manufacturing Plants ', by John A. Shubin and Huxley Madeheim. *N.Y., Prentice-Hall.* 1951. 433 *pages. Illustrated. Diagrams.* £2 10s.

This book may be divided into three major divisions:—

1. Factors which influence plant layout.
2. Techniques and methods.
3. Materials Handling and industrial buildings.

Emphasis is given to the influence of product design in the selection of equipment and in the determination of the type of layout to be developed. This is followed by a brief survey of the techniques and tools used in the conventional production analysis. Following this the influence of location on plant layout is discussed, giving several examples taken from American industry.

The second section, plant layout, tools and techniques, starts with a discussion of process charts, and proceeds then to the consideration of the use of drawings, templates and scale models.

There is a detailed discussion of the comparison of product and process layout which includes the advantages and disadvantages of each type. The problems of layout are separated into two parts,

(*a*) the layout of a new plant
(*b*) the revising of existing plant layouts.

The third section, concerned primarily with Materials Handling, discusses the general characteristics of a number of various types of handling equipment. The section is completed by a chapter on industrial buildings which includes a discussion of the types of buildings, their design and the construction materials available for use.

535.4 INTERFEROMETERS

" Modern Interferometers " by C. Candler. *London, Hilger & Watts Ltd., Hilger Division.* 1951. 502 *pages. Illustrated. Diagrams.* £2 17s. 6d.,

This book aims to describe interferometers in general use, together with sufficient theory to explain their operation. The first chapter is devoted to the principles and general uses of interferometers. National and International standards of length are considered, together with tables of the results of the more important determinations of the metre in terms of light waves.

Michelson's original experiment for the determination of the metre is fully described, also the Fabry-Perot interferometer used for most of the more recent determinations of the metre. Other interferometers for gauge measurement are described, including Koster's gauge interferometer, the N.P.L. gauge interferometer, and the instruments developed by Dowell for the measurement and comparison of both slip gauges and angle gauges.

A full description is given of the prism and lens interferometers developed by Twyman, and the subject of diffraction gratings is considered, including a chapter devoted to their manufacture.

621.793 METAL COATING

"Protection and Electro-deposition of Metals." Ministry of Supply. *London, H.M.S.O.* for *Technical Information and Documents Unit.* 1951. 350 *pages. Illustrated. Diagrams.* £1 10s. (*Selected Government Research Reports Vol.* 3.)

Thirty-three reports are given in this book, divided under the headings of "Protection of Metals" and "Electro-deposition of Metals." The general bias is towards work on the light alloys such as magnesium and aluminium, but in the second part of the book on electro-deposition, the reports are more generally applicable.

The individual reports are of a somewhat technical nature, and except for the brief abstract at the start of each report, they are designed essentially for the professional and full-time metallurgist.

621.791 WELDING

"Electric Arc and Oxy-acetylene Welding" revised by W. A. Atkins and A. G. Walker. (4th Ed.) *London, Pitman.* 1952. 352 *pages. Illustrated. Diagrams.* £1 10s.

A work dealing with welding by Electric Arc and Oxy-acetylene from the practical point of view.

Chapters cover the methods of joining metal that are in vogue at present; a short history of the development of the Electric Arc; advantages and disadvantages of A.C. and D.C. for electric welding. Preparation of joints and motions of travel for the electric arc, including the over-head welding theory, practical hints and "Dont's" for the welder, stress being placed on safety.

The work then turns to gas welding with comparable chapters as those outlined for Electric Welding.

The remaining half of the book takes both Electric Arc and Oxy-acetylene welding together. It explains metal cutting and the effect of expansion and contractions, which is dealt with to some length. Weld defects and testing illustrated by some fine micro-photographs of weld and parent metal, selection of feed wires, rods, electrodes and fluxes together with the welding of alloys and properties of metals.

To conclude the work a summary of commercial plant and accessories is given finalising with the training of welders, examinations and regulations.

016 BIBLIOGRAPHIES

"Index Bibliographicus: Directory of Current Periodical Abstracts and Bibliographies. Vol. I., Science and Technology" by Theodore Besterman. (3rd Ed.) (Rev.) *Paris, UNESCO; The Hague, International Federation of Documentation.* 1952. 52 *pages.* 6/6.

This third edition of a standard library and research tool gives a selective list of publications which contain abstracts or bibliographies. It covers the fields of science and technology, and is arranged by subject with an index of titles. A second volume, covering the social sciences, education and humanistic studies is planned.

669.71 **ALUMINIUM**

"Aluminium and Magnesium, Design and Fabrication" by R. Burt Schulze. *N.Y., McGraw-Hill.* 1949. 589 *pages. Illustrated. Diagrams.* £3 12s. 6d

All known American methods, employed in the manufacture of articles, from aluminium and magnesium sheet, particularly aircraft components, are described, together with many actual examples of time studies, from the tool pattern to the finished part.

The book is well illustrated, especially in regard to machine set-ups, and the chapter on cost analysis emphasises the factors to be studied for efficient production.

OTHER ADDITIONS

621.38 **ELECTRONICS**

"Electronic Applications in the Machine Shop and Factory." *London, Machinery Publishing Co.* 1951. 58 *pages. Illustrated. Diagrams.* 4/–. (Machinery's Yellow Back Series No. 28A.)

621.438 **GAS TURBINES**

Fiock, Ernest F., and Halpern, Carl. **"Bibliography of Books and Published Reports on Gas Turbines, Jet Propulsion, and Rocket Power Plants."** *Washington, U.S. Gov. Pr. Off.* 1951. 64 *pages.* 20c. (U.S.A.—National Bureau of Standards—Circular 509.)

621.73 **FORGING**

Naujoks, Waldemar, and Fabel, Donald C. **"Forging Handbook."** *Cleveland, American Society for Metals.* 1948. 630 *pages. Illustrated. Diagrams.* £3.

621.74 **FOUNDRY WORK**

Cady, Edwin Laird. **"Precision Investment Castings."** *N.Y., Reinhold.* 1948. 356 *pages. Illustrated. Diagrams.* £3.

New Jersey Zinc Company, New York. **"Practical Considerations in Die Casting Design."** *N.Y., The Company.* 1948. 246 *pages. Illustrated. Diagrams.*

Rosen, C. **"Centrifugal Casting by the Cire Perdue Process."** *London, Contact Publications Ltd.,* for *David Wallace Ltd.* 1949. 204 *pages. Illustrated. Diagrams.* £2 12s. 6d.

621.775 **POWDER METALLURGY**

Goetzel, Claus G. **"Treatise on Powder Metallurgy. Vol. III, Classified and Annotated Bibliography."** *N.Y., Interscience Publishers.* 1952. 899 *pages.* £8 16s.

621.793 **METAL COATING**

Ingham, H. S., and Shepard, A. P. **"The Metco Metallizing Handbook."** (5th Ed.) *N.Y., Metallizing Eng. Co.* 1951. 249 *pages. Illustrated. Diagrams.* £2 2s.

621.822 **BEARINGS**

British Timken Ltd., Birmingham. **"Engineering Handbook: Dimensions and Information Relating to Load Carrying Capacity, Method of Selection and Fitting Tolerances."** (Home Ed.) *Birmingham and Duston, The Firm.* 1951. 82 *pages. Illustrated. Diagrams.*

621.86 **MATERIALS HANDLING**

Barry, Jack K., and others. **"Paper Handling Practices."** *Madawaska, Maine, Fraser Paper Ltd.* 1951. 74 *pages. Diagrams.*

Robins Conveying Belt Co., U.S.A. **"Handbook Material Handling Equipment made in England by Fraser & Chalmers Engineering Works, Erith, Kent."** *Erith, Fraser & Chalmers.* 1927. 322 *pages. Illustrated. Diagrams.*

Industrial Instrumentation and Automatic Process Control

A series of lectures and demonstrations on Industrial Instrumentation and Automatic Process Control has been arranged by the Electrical Engineering Department, Battersea Polytechnic, London. The series, which is under the direction of Dr. G. L. d'Ombrain, Ph.D., B.Sc. (Eng.), is intended to introduce Engineers, Physicists, and Chemists to the possibilities of automatic control.

The majority of the lectures will be supplemented by the demonstration of actual control and measurement apparatus loaned by a number of participating firms. Those taking the Courses should have the equivalent of the B.Sc. Degree, H.N.C. or professional institution status. Knowledge corresponding to such standards will be assumed, but no prior knowledge of the Process field will be assumed. The Course is not suited to those only interested in instrument maintenance.

Full details of the Courses, which begin in the Autumn Term commencing on the 2nd October, may be obtained from the Electrical Engineering Dept., Battersea Polytechnic, Battersea Park Road, London, S.W.11.

Course in Production Engineering

A whole time College Certificate Course in Production Engineering, extending from October to June, has been arranged by the Department of Engineering, King's College, University of Durham. The Session, which begins on the 7th October, is open to Graduates in Applied Science and to holders of a Higher National Certificate in Engineering, although students who do not comply with these regulations may be admitted by the Academic Board on the recommendation of the Head of the Department.

The Course is broad in scope and covers aspects of industry not normally the subject of formal study. Extensive laboratory facilities are available and, in addition, students are required to devote part of the Easter vacation to the study, under supervision, of production problems in factories in various parts of the country. Considerable importance will be attached to the writing of technical reports.

Further details of the Course may be obtained from the Registrar, King's College, Newcastle-upon-Tyne.

(*NOTE:* In addition to the Colleges listed in the Journal for August 1952, The Denbighshire Technical College, Wrexham is now offering courses in Production Engineering).

Courses in Statistics

A recent development at Cardiff Technical College is the inauguration of Courses in Statistics covering syllabuses for the examinations of the Royal Statistical Society and the Association of Incorporated Statisticians.

During the 1952/3 Session it is intended to attain the Intermediate standard of the qualifying examinations, while the Final Course will be available in the 1953/4 Session.

It is hoped that these Courses may meet a need in providing a comprehensive training for Statisticians whose value to Industry, particularly Production Engineering and business administration, is becoming widely recognised.

Tolerances, Limits and Fits

The Engineering Production Department of the Northampton Polytechnic has arranged a course of lectures on "Tolerances, Limits and Fits and Their Application to Engineering Design and Manufacture."

The course, which commences on the 6th October, 1952, is intended to cover the two new British Standards B.S. 308 Part II, Engineering Drawing Office Practice, Dimensioning and Toleranc-ing, and B.S. 164, Part I, Limits and Fits for Engineering. It will consist of three separate subjects, Dimensioning and Toleranc-ing, Limits and Fits, and Engineering Metrology, and whilst the three subjects are intended to form a balanced course, they may be taken separately or collectively as desired.

Further particulars may be obtained from the Principal, Northampton Polytechnic, St. John Street, London, E.C.1.

The Library

Members are asked to note that the Library will be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week, and from 9.30 a.m. to 12.30 p.m. on Saturdays. Due to Meetings, the full facilities will not be available at the following times:

Tuesday, 7th October, from 12 midday.
Wednesday, 8th October, from 2.30 p.m.
Tuesday, 21st October, from 11 a.m.
Tuesday, 28th October, from 12 midday.
Thursday, 30th October, all day.

Journal Binders

Members are reminded that binding cases for the Journal are obtainable from Head Office, price 7/6 each post free. The cases, each of which will hold 12 issues of the Journal, are made of stiff board covered with imitation leather cloth, with gilt lettering on the spine.

Research Publications A number of copies of the following Research publications are still available to members, at the prices stated:

Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research & Development	10/6
Practical Drilling Tests	21/-
Test Charts for Machine Tools, Parts 1, 2, 3, 4	6/- each

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge," Melton Mowbray, Leics.

Issue of Journal Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

Important In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

MACHINE CONTROL
The Use of Comparators for Production

by J. D. RICHARDS and R. YRIBARREN

Presented to a General Meeting of the Institution in London, 3rd July, 1952

ALTHOUGH gauges were originally evolved for use purely and simply by the individual producing the part to be checked, gauge design at a certain point in engineering history, became a mere camp follower of production methods.

Partly from mistrust of the reliability of the machine operator as opposed to that of the machine tool, partly from the ability at that time of the good machine tool to produce to greater accuracy than was then normally required, all that seemed necessary was the creation of a watchdog to guard against occasional rejects which might be produced by the machine operator.

Once the watchdog was thoroughly established, the rapidly developing situation brought about a growth and characteristics far different from those initially in the minds of the very many engineers who inaugurated an Inspection service in their own factories.

Gauge development, as longer production runs and increased interchangeability mushroomed into existence, became limited until comparatively recently almost completely to methods of sorting finished parts and eliminating any faulty ones, in a department placed apart from the workman who produced them.

Once committed to such a method, change is difficult. But it is certain that there was initially widespread underestimation of the future difficulties of holding close tolerances in production on many widely used types of machine tool.

So, the physical and psychological relationship between Inspection and Production are today far removed from that originally foreseen.

It is no new thesis to trace the evolution of our average present day organisation in the matter, but it is of value to recapitulate the inevitable movement towards creation of an impartial judge, who wherever sympathies might be, is bound by carefully defined limits of tolerance outside which no sympathy can carry him. From such a recapitulation, a resurvey can be made.

For, as with judges, hard cases do not make good law, so production difficulties cannot excuse the Inspection passing faulty dimensions.

The relationship between Inspection and Production is so widely known as to have become the subject for a good deal of humour—this is fortunate, in that such humour has at least enabled personal friendships to exist across the iron curtain which separates them in

so many cases. But shaking down or rubbing along together has to an extent camouflaged the real need for a radically different outlook and organisation.

The growth of the dimensions—space, staff, equipment and need for handling—of the Inspection department dates from the earliest putting of measuring instruments into the hands of an individual who was not the actual machine operator himself.

As ten thousandth parts of an inch replaced thousandths, as production rates grew, as the employment of unskilled labour became not a matter for long term training but an immediate item for mass-application to the average production organisation, so the Inspection Department, created to prevent passing of the odd reject in a comparatively leisurely way, was deluged with new problems.

To deal not only with a huge increase in the number of parts produced and offered up to the Inspection, but also with considerable increases in the reject rate, increased space and staff were provided, new and ever more searching equipment was installed.

The Inspection, as its only defence against the equally understandable blandishments of the harassed Production, was forced to retreat behind impartiality in its dealings.

Combined with this, the well known former tendency of design staff to impose unduly close tolerances, no doubt partly to ensure that variations should be at a genuine minimum, led to the Inspection becoming feared by the Production—in quite an impersonal way, of course.

An important point in the summarising of the situation is the difference, in the visualising of dimensions, existing between Inspection and Production. The Inspection is always inclined, even when at its most helpful, to think in terms of limits—undersize, correct or oversize parts. The Production must think in terms of size, and is closely interested in the size of a part even when it is within the tolerance.

But the weight of development of gauges, being done on behalf of the Inspection department, has been largely on limit gauges. And the consequence for the Production has been that it is frequently possible, immediately and automatically to obtain sizes on rejections or acceptances, but that the very instruments set aside for use by the Production have also been limit gauges, and usually of a very simplified character.

The Inspection thus are unable to give the best possible aid to the Production partly because the latter are without the means to make really good use of such help.

It is true to say that metrology, the faithful servant of standardisation, has been devoted to developing more and more efficient ways of finding the faults in the production. This comes too often too near to being taken to be finding fault *with* the Production.

Pursued to the ridiculous, it might even be said that, working on these lines, the value of the Inspection department could be measured by the value of the rejections it manages to achieve.

But, human nature being what it is, a formula for working under the existing convention has of course sprung up. A modern Inspection organisation nearly always takes upon itself the extra duties involved in being as constructively helpful as possible, and at least apparently reasonable results are obtained in this way.

But the question remains as to whether in fact the overall convention itself should not be altered.

Workable as the present system has been, both market requirements and technical advances on other lines in the last decade have put an increasing pressure on the existing structure.

One result has been the extreme uneasiness of top management over the increasing overhead costs represented by Inspection staff and equipment, and the ancillary services required to operate for the former.

While a very big part of the problem is the question of the inspection of parts obtained from outside sources, where the use of limit gauges is obviously perfectly adequate, some drastic measures must be taken to reduce the liability of machining errors more nearly to the level of inspection errors in even this case. This could allow of entirely different methods to be employed by, for example, Government Inspection Departments.

The use of green labour in huge quantity for this type of inspection brings with it its own special problems, so it is proposed within the scope of this discussion to limit ourselves more to internal matters, and in particular those concerning machining operations based on the movement of machine slides.

The Problem

It has often been stated that it is a pity to produce parts only to discover, when it is too late, that they are unacceptable. It is a cliché to suggest baldly that the only solution to improving quality and reducing rejects is to make the task easier for the machine operator.

But the classic organisation of production factories was evolved without taking either of these ideas into proper consideration.

As a result the situation outlined in the foregoing came about, and foreseeable future developments in metrology are now granted to be along two lines : automatic sizing—where the gauge is to be applied to the part while machining proceeds, stopping the machine when size is reached ; and 100 per cent. automatic inspection by checking equipment, often multi-dimensional, placed beside the machine.

Both these ideas will be gone into more fully later on, but we must say that it is our opinion that they are both very largely improvements of the wrong sort, and both far from being realisable for

many years to come without the likelihood of introduction of risks of error greater than the risks they are specifically designed to eliminate.

Both are indisputably an endeavour to lessen the influence of human intervention.

It is however necessary to consider the possibility of metrology providing the means of re-establishing the position the workman occupied when gauges were first evolved. Gauges at that time gave him the means to stay comfortably inside the boundaries of the accuracy demanded of him.

It was only when requirements passed outside the limits of his normal perceptions that the operator began to produce reject parts —and the core of the contention being outlined here, is that the most important step now, is to equip the machine operator with a third eye, capable of placing him in the position of being the master of his job.

If this is done, and it can be done, it is found that the " human machine " has an absolutely unbeatable suppleness, and is in fact the very best factor in the economic running of a business.

From the foregoing it might appear that we are laying a grave responsibility at the door of metrology, but there is naturally a very good explanation of the role played by metrologists in past developments.

Until recently, high quality gauges were physically limited to Standards Room use, by reason of their very fragility ; this was particularly true of indicating gauges. To have attempted to place high magnification indicating instruments in the hands of machine operators would have been disastrously expensive.

This problem is solved however, and there exist comparators on various different basic principles which now can be used in this way.

The significance of such a suggestion is in the effect on dispersion achieved by comparators used in particular ways on the machine itself, and the repercussions and implications of the results which will be found.

The function of engineering tolerances is to cover the maximum acceptable variations in the size of a part or parts due to process variability—which we loosely term dispersion. This variability or dispersion may be inherent in the machine and machining set-up, or may simply come from the vagaries of manipulation of the same by the machine operator.

The well known, if highly schematic, graph representing this (Fig. 1) shows the three factors which exist ; firstly, the centering of the size inside the tolerance, or the initial setting of the machine as it often is ; secondly, the spread of process variability in the machine and its condition of working, and lastly the rate of wear of the wheel or tool.

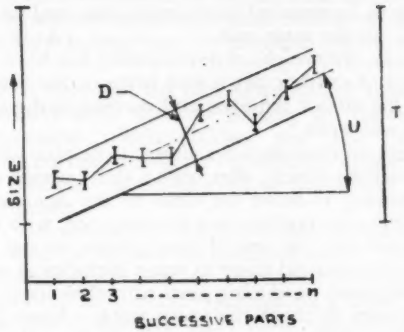


Fig. 1

On a one-off job the first two of these factors are equally found, and as much value attaches to the same attention being given to them.

Thus the solution offered by Machine Control is specifically based on the idea of making easy the sure centering of the dispersion zone inside the tolerance, and towards reducing the width of that dispersion zone.

On the first point, two elements may vary widely : skill of the operator, and quality of the machine tool. In many spheres it is considered that as soon as a certain accuracy has to be held, very highly skilled operators must be used if tolerances are to be respected. There are as we know, men who can produce, if not at a fully acceptable speed, to extremely close limits.

But there is no question that even such an operator cannot say if he has correctly centred himself in the tolerance. This centering is very important in fact, as it is the only basis for starting from. He can only modify our classic graph by reducing dispersion due to operator error—and this error can be seen further reduced if a comparator is put to suitable use ; in this latter case, completely unskilled labour can now be used, at the same time covering the question of centering in the tolerance, both initially and to offset effects of wheel or tool wear.

As an alternative to skilled labour, recourse may be had to very high quality machine tools. Not only are these very expensive in the first place, but it will in fact be found that the replacement rate is also rather higher than is considered normal in this country, if accuracy is to be maintained.

Experience shows in any event, that this solution is not entirely successful of itself. Although a great deal of progress has been made

in machine-tool design over the last fifty years, these improvements relate mostly to increase of production rate and of facilitation of manipulation, to the same end.

That is to say, the weight of development has been directed upon all the aspects of cutting down cost price of the article produced, by reducing the labour required and increasing the speed at which the machine will work.

Nevertheless, no manufacturer claims to be able with certainty to produce a machine which, after only a short period of use, can be used with certainty to move the slides by say .0001 in. or to return the slides to the same position as a previous one, with that accuracy.

In this connection, the use of limit gauges on the machine is of interest ; it is no unusual thing in many factories to see operators—skilled or otherwise—producing parts with close limits on them, and using limit gauges to check their own work. Apart from questions of feel, they have little or no indication of where they are as size is approached, nor of whereabouts the finished part is, irrespective of whether it is inside or outside the tolerance.

However, the necessity in most cases for 100 per cent. inspection of parts machined to limit gauges is the best proof of the latter's fallibility.

If the tolerance is wide enough in relation to manufacturing dispersion, the machine and operator will easily enough produce acceptable parts.

It is amusing to see, as often happens in the same shop, an operator working to a limit gauge, while a few yards away there is an automatic or a press easily holding as close, or closer, tolerances.

But if the tolerance/dispersion factor is approaching unity, either the operator is unskilled and has to grab at a fast disappearing size without being sure of what he is doing, or else the operator is skilled enough to " sense " a tenth and is an artist who is but slightly aided by a limit gauge anyway—and moreover such men are rare, expensive and only of reasonably high output at best.

The use of limit gauges therefore does not help manufacture at all. They shift the problem to the Inspection Department, but it remains present in whole. In fact, once shifted away from the machine, the problem of accurate sizing becomes definitely insoluble.

We may therefore examine the reasons for picking on slide movements as the most important factor in the problem. There are two aspects of the question : the movement of slides by a known amount, and the movement of slides to a known position. The latter is the same as saying the exact determination of slide position relative to size of part produced at that position.

There are of course many other factors causing dispersion such as bending or other deformations, vibrations, influence of the method of holding the work, play in various parts, errors of centres, taper and so on.

Slide movements are however by far the most important of these causes of dispersion, and it will be found moreover that attention to this point provides in large part the means of dealing with the rest.

Automatic Sizing

It is here that the idea of automatic sizing arose. It would seem that by placing an instrument on a machine which follows the size of the part during machining, the operator could stop the machine when size was reached ; it might even be possible to perform this entirely automatically.

Theoretically this solution is most attractive and should, it seems, allow any machine to be used for precision work. This, we well know, it does not do and in practice the use of continuous or automatic sizing devices is generally limited to plunge grinding on centres or mandrel. There are other cases where it may be used but these generally imply a machine of such specialisation as to be too inflexible for use on any but the very biggest mass-production runs.

The possible drawbacks of automatic sizing as opposed to in-feed gauging have been gone into before,* but to make precision measurements certain conditions must be respected. For centreless, cylindrical or internal grinding, turning, milling or boring, there is no real way of measuring the part while machining is actually going on. It is far from easy to overcome problems of perpendicularity, contact, setting, resistance to shocks and vibration, space available and so on.

In practice, the Arnold gauge or its derivatives are the only practicable solution to any of these problems.

Automatic Inspection

Considering merely the use of automatic multi-dimensional gauges placed beside the machine, sometimes hopper-fed, it would seem that these, acting more as a production gauge than as an inspection gauge, might be of great assistance on close limit work in the catching of faulty parts on the spot as they are produced.

Particularly if the means are available to use them for correcting the machine as often as necessary, such instruments are in theory closely allied to the idea behind Machine Control.

However, setting aside their cost and specialisation there are some considerations which may suggest the advantages of a different method. Such gauges are apparently of most value for use with automatics, and in forming almost a running Quality Control chart. They must then be of the indicating type, if they are to be more than mere danger signals.

* "The Theory and Practice of Machine Control." pps. 8 and 9 publ. Solex (Gauges) Ltd.

It is often found, in the very sphere where such gauges should be of the most value, that they are of the least, since their mechanical complication renders them liable to troubles (mostly from going out of adjustment) the likelihood of which is as great or greater in effect than those inherent in the machine which they set out to watch over. It is sometimes argued that the success apparently achieved has been at the cost of unconsciously under estimating or ignoring altogether some aspects from the sum of the overall results over a period of use, that is to say, by forgetting the difficulties of the means in enthusiasm for the end.

To use setters' gauges—or setting check gauges as they are sometimes called—which are more of an individual, manual, nature, can usually provide an equally good or better result, at a fraction of the cost and complication. The automatic gauge, checking—usually unnecessarily—every component, is subjected, with all its moving parts, to a much higher rate of wear.

The most important characteristic of a good gauge must always be simplicity—in design and in operation. The supreme quality of good gauges is dependability, and simplicity is the only way of achieving this. Otherwise, *quis custodiet ipsos custodes?*

The Possibilities

The problem summarised is therefore largely to make use of indicating gauges or comparators, on the one hand to show the machine operator what size he has produced, and on the other hand to render easy the translation of this result into suitable manipulation of the machine tool.

The immediate results are to make easy the initial setting of the machine, to reduce the spread of dispersion, and to correct in good time the influence of tool or wheel wear.

The technique stands wholly upon high magnification allied to robustness.

Indirect, but not less interesting, are the possibilities opened up by the results found. The first and most important in fact, is the releasing of Inspection from its impartial role, to become a very active and powerful aid indeed in production matters.

Apart from savings in view room staffs, space and handling needs, Inspection can readily make itself responsible for the surveillance of process variability in various machines. This allows the application of a system complementary to Quality Control and of a very much greater degree of simplicity, whereby faults in, or deterioration of, inherent accuracy of the machine and its set-up can be simply and efficiently dealt with.

Usually, surface finish is automatically improved for reasons which will be gone into, unskilled labour can be used on precision

jobs, closer tolerance limits can be applied without decreasing speed or increasing rejects, and better use made of machines which had seemed a little past their best.

Viewed in the light of all the foregoing it will be seen that metrology enters into every aspect of the problem, though it is little applied to the core of it. This metrology is capable of being applied, once suitable instruments are available.

Suitable Instruments

Up to this point, all that has been said applies equally to any type of measuring instrument, but the question of the practical application to production of magnifying comparators will be discussed purely from the experiences made, using air as a medium of gauge operation.

Nonetheless general conclusions apply equally to mechanical, electrical or other types of gauges, and it is merely by reason of the data available relating to air-operated gauges that a specialisation on one make of this type is to be found here.

There are some inherent advantages attaching to air-operation which also make it perhaps the most interesting method of meeting the requirements.

Though these were not all evident to the full when Marcel Mennesson first invented the use and evolved the basic principle of air gauging, it has been found nevertheless that he had provided all the chief prerequisites from the start.

Briefly, the instruments to be put in the hands of machine operators must be, as has been said, of the indicating type. They must have high magnification of the order of $\times 2{,}000$ to $\times 7{,}000$ or higher. They must be sufficiently sturdy in construction to withstand the rigours of an existence in the works, and to remain reliable withal.

There are other and apparently minor advantages, which may have surprising importance. Perhaps the best instance of one of these is an experiment carried out fairly recently at Volkswagenwerk in Germany by Herr Orlich, their Chief Inspector.

This was a comparison of the results obtained, over a month in each case, with two types of comparator checking and grading gudgeon pins.

The first comparator head was an electrical one and the second an air-operated. The stand, its position, the operator and all other conditions of working were kept the same.

The electrical head has of course a very high speed of response, whereas the setting of the air-operated one used was giving at a magnification of $\times 12{,}000$, a speed of response of over 1 second.

However, the number of parts checked rose with the air-operated head, from the 20,000 of the electrical head, to 56,000.

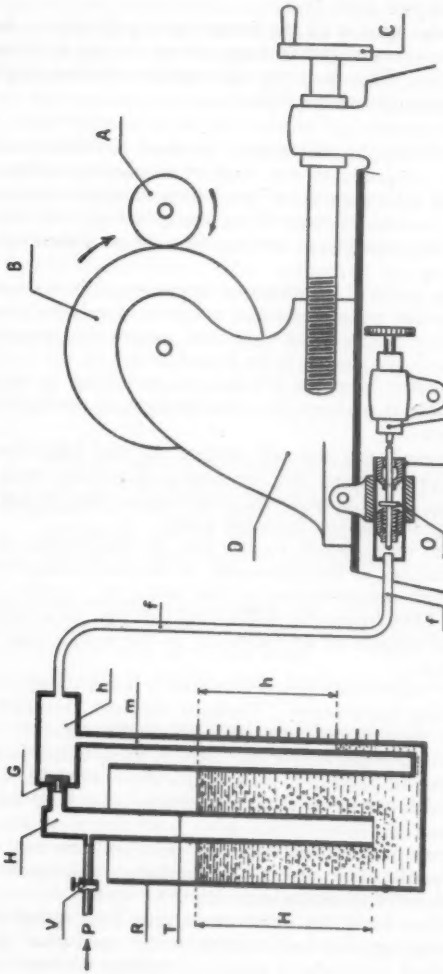


Fig. 2a

Schematic diagram of Feed Gauge.

It seems at first sight hard to explain why an inspector should be able to check nearly three times the quantity of parts with an instrument which was ten times as slow in response.

Careful investigation apparently showed that the reason was the reduction in operator fatigue. The high magnification employed with the air-operated head, and the vertical movement of a blue-green manometer column against a white background allowed the inspector to carry on regularly throughout the day.

A similar phenomenon is noticed on multi-gauging where, comparing two types of air gauges, one using Bourdon type dials such as were used for cannon shells in the last war and the other using manometer columns, operators on the dial type tend to become rapidly bemused, the rotational movement of a number of needles over closely spaced divisions soon ceasing to be observed at sufficient speed to match handling of the parts into and out of the gauge.

In the Volkswagen experiment, the value of the increased inspection rate was in fact not to enable more components to be checked. The rate achieved allowed the output figure to be far more than met, but the easing of the work was most important. The probability of parts being wrongly graded or accepted was more than halved.

This is a point of the greatest significance in organisations where a great deal of unskilled labour has to be used on inspection.

It has been argued that the use of very high magnifications is dangerous, since it may well lead to difficulties in obtaining real accuracy, and also encourage engineers to undertake work which is too difficult in fact in proportion to the precautions which will be taken in other directions.

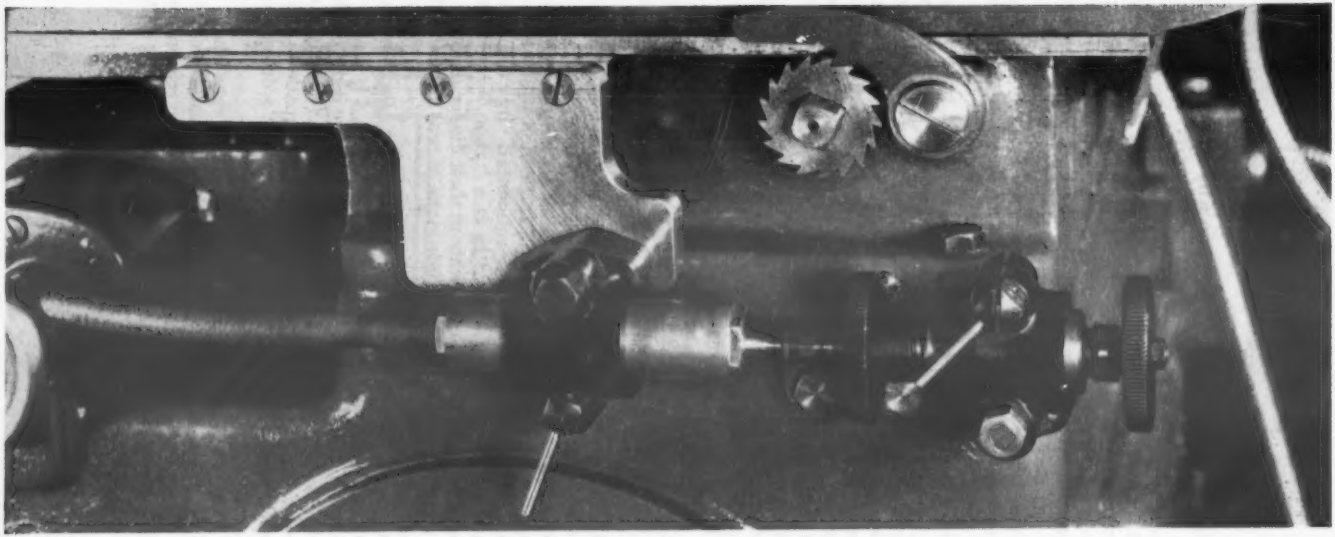
It is true that such fears are justifiable if these high magnification instruments are strictly reserved for an Inspection which is independent of Production. Designers, influenced by the ease with which variations of a few hundredths of a " thou." can be shown, may then become a little immoderate in their choice of limits ; and for the same reason, others may lose sight of real values of dimensional variations.

But when such comparators are used by Production very different results are achieved.

The most striking example within our knowledge is the production of a crankshaft for a small two-stroke engine. A closely watched experiment, covering over 150,000 crankshafts made in the Velo-Solex works in Paris during three years is perhaps worth going into fairly closely.

Two external diameters are ground on the crankshaft, being respectively 15 mm. and 17 mm. with the unusually close (unilateral) tolerance of ·003 mm. or ·00012 in. The reason for these limits being imposed is to ensure correct form being obtained.

Fig 2b



Feed gauge mounted on cylindrical grinder.

One operator deals with two machines, each equipped in the following way. Beside the machine is a vertical comparator, equipped with a suitable fixture on its table. Mounted on the machine itself is a second indicating instrument, connected to a poppet type comparator unit mounted on one slide of the machine, and abutting against an adjustable stop on the other slide of the machine. This is what is called the Feed Gauge. (*Figs. 2 a, and b.)*

The first component is ground and measured on the vertical comparator. According to the result found, the stop of the Feed Gauge is adjusted, to show a reading corresponding to this size and the stop is locked. The infeed wheel is manipulated until the level in that manometer column reaches " 0," when the part is removed for checking, a second component having been inserted and the machine restarted, initially on automatic in-feed, to ·0008 in. of size.

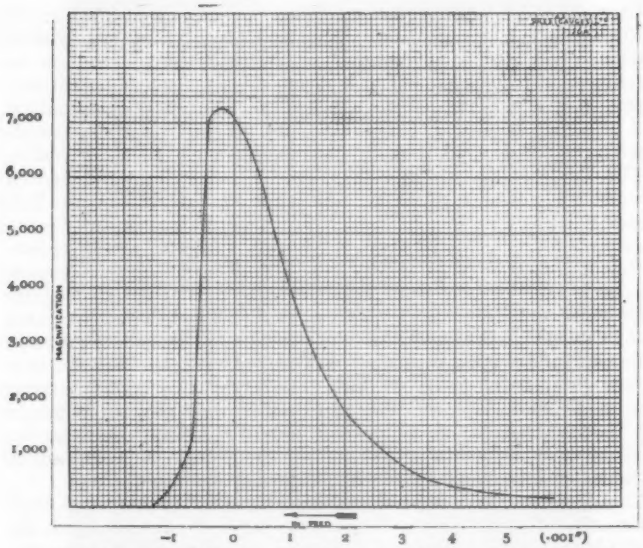
During this period of automatic operation, the machine operator deals with the second machine, returning to the first to take over for the final cuts, which he makes by watching the manometer column of the Feed Gauge descend to "0," when the part is removed and checked. As the size of the component gradually increases due to wheel wear, this is measured and a corresponding amount added to the in-feed as shown by the Feed Gauge.

An indication of dispersion of the machine and its set-up is automatically given by any differences between the results shown by the Vertical Comparator and the Feed Gauge, and the operator himself very quickly finds he can give an exact value for this dispersion from day to day. Of course any accidental movement of the slides is at once shown by the Feed Gauge.

In this example entirely unskilled operators are used on what is a very high precision job at a high production rate. The operator, in fact, due to the high magnifications employed, has no idea of the real smallness of the tolerance. He finds it quite simple to remain inside it, and is thus not worried by it. After a few hours, he is capable of changing size or wheel dressing, without a setter's help.

On the quantity of crankshafts produced, rejects for dimensional causes fell to less than ·1 of one per cent., and Inspection as such on the job has been completely removed, components going direct from the machine to the Assembly.

However the Inspection Department still has a say in things—in fact a very much more important one. Apart from random sampling against their own masters (checking the setting of the gauges at the same time) the Inspection are responsible for the preventive maintenance of machines and investigation of the reasons for any dispersion observed. The Inspection are actually capable of giving warning before a machine reaches the point where it is no longer capable of doing the work asked of it, and they play a large part in advising as to methods of " picking-up " jobs.



Variation of magnification coefficient in relation to size: Feed Gauge.

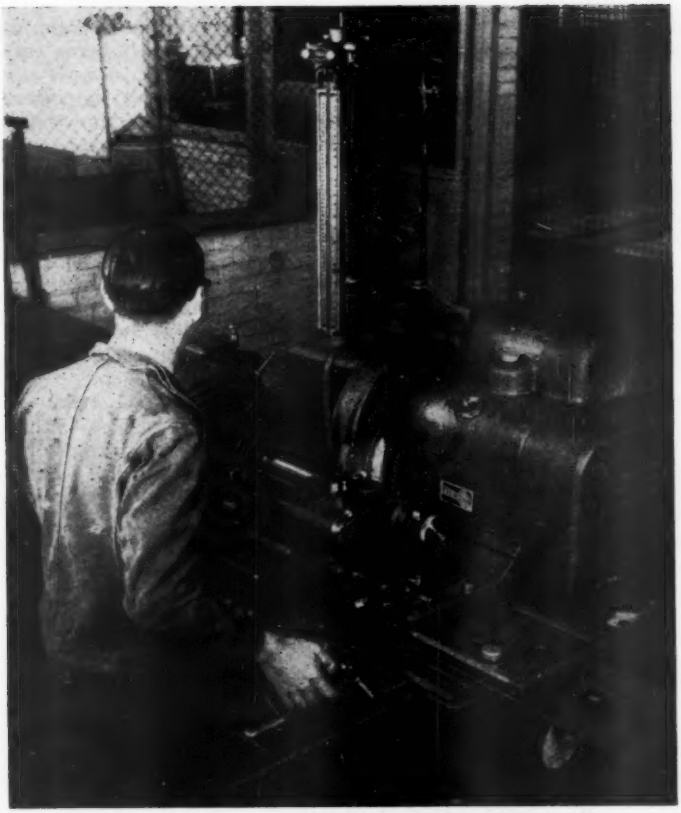
Fig. 3

The magnifications employed in this case, in common with usual practice in such matters, are of very great interest.

The Vertical Comparator is set at about × 12,000, which allows the operator to judge very accurately where he is within the close limits.

The Feed Gauge has a maximum magnification of about × 7,000, on a non-linear scale (*Fig. 3*). As size is approached, so the magnification rises rapidly. This means that the manometer column drops with ever increasing rapidity. In effect, the operator, watching the column all the way down, is forced to slow up his in-feed rate progressively as size is approached.

From his point of view, the manometer column only begins to move downwards, and that slowly, at ·004 in. from size—giving a warning in fact. Early increment divisions (at the top of the scale) are in ·0005 in. steps and fairly close together. But as machining proceeds, the column drops through divisions representing smaller and smaller amounts, the last two or three " tenths " being widely spaced. The operator therefore is automatically using the optimum



Finishing a part using Feed Gauge indications.

Fig. 4

rate of finishing, and is finishing each part with the same pressure of cut. The effects on surface finish and regularity of form, between part and part are remarkably good.

Thus, without any complicated mechanism, the same or better results are found as with other more specialised devices.

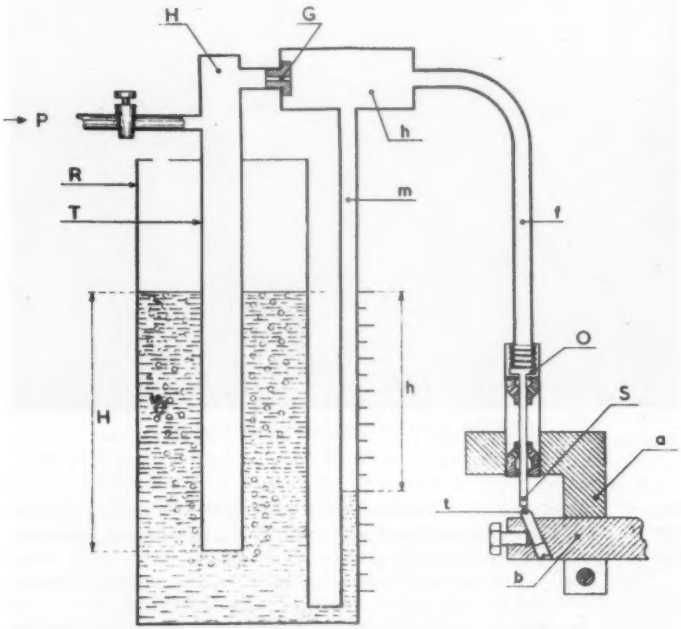
There is another characteristic of the type of gauges under discussion, and that is the ability to position the gauging head as is best on the machine, while the indicating part of the instrument is

installed in the most convenient place for the machine operator to see it (*Fig. 4*)—the two parts of the installation merely being connected by a piece of flexible tubing of suitable length.

The last characteristic worth mentioning here is a very important one, viz. the degree of robustness compared to the accuracy and degree of magnification obtainable.

Various makes of air gauges work on a number of slightly different principles, bu many of them are noteworthy for their complete absence of any amplification " mechanism " whatsoever.

Air at a constant pressure may be passed through what is known as a control jet, which meters the maximum flow at that pressure, thence passing to the measuring orifice the size of which is controlled by the dimension of the part being measured. It is solely the relation in cross-sectional area of the control jet to the measuring jet which establishes the magnification coefficient—as one might say,



Schematic diagram of Tool-Setting Gauge.

Fig. 5

the degree of exhausting the pressure intermediate to the two jets in relation to a known change in effective escapement area of the measuring jet.

In practice this not only obviously adds to reliability, but when linked to a water column having a certain amount of inertia, there is an absence of the effects of vibration—both constant and spasmodic.

It need not be stated that this inertia does not of course affect accuracy, and in fact some of the highest precision instruments, produced on the basic principle outlined, have been based on the advantages of this inertia.

While concentration has been made on slide movements in the foregoing, there are many cases where tool-rotating machines can be similarly treated. The type of feed gauge used (*Fig. 5*) is known as a Tool Setting Gauge to distinguish between it and the classic Feed Gauge. The principle is the same—measurement by the Production Gauge, and translation by the Tool Setting Gauge. As will be seen, the latter is a comparator unit in a suitable adaptor. After measurement of the part the adaptor is clamped on, say, the boring bar; the comparator unit is adjusted to give the reading corresponding to the amount the part varied from nominal. The comparator is then locked and the tool-bit is moved in the bar, until the Tool Setting Gauge reads zero. The tool bit is clamped, the gauge removed from the bar, and machining proceeds.

With the prerequisite of security always in mind there is, however, no doubt that other methods or basic principles could be used for the same results. But the basic ideas of highly magnified size-indications, robustness and reliability are a *sine qua non* in practice, and must at all times be in the forefront of engineers' minds in connection with Machine Control.

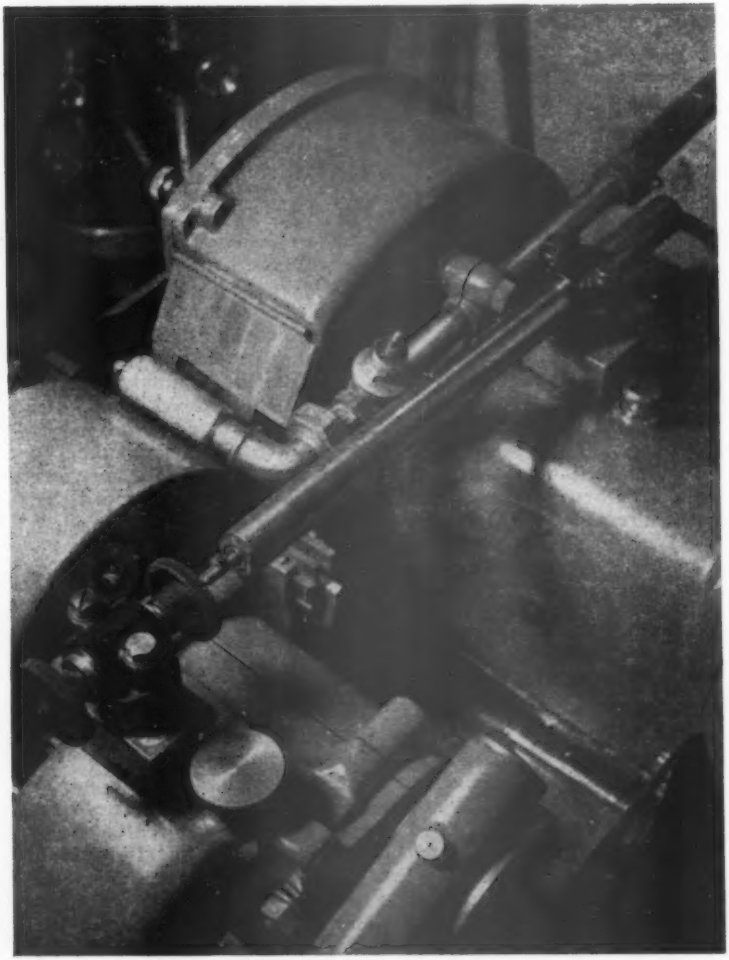
The Equipping of Machines

In spite of the diversity of machine tools which can be equipped with comparator units, certain general rules may still be laid down.

No matter what the machining operation may be, the equipment should always be in two parts (*Fig. 6*). The first is the Production Gauge, allied if necessary to a setting check gauge for variations outside the machine operator's control. The second is one or more comparators fitted to the machine itself to ensure correct and simple manipulation of it.

The choice of the Production Gauge depends naturally on the work to be done. An adjustable gauge usually covers one-off jobs, and a fixed gauge or only semi-adjustable gauge will cover production runs. Either may be gauged to work type or *vice versa*.

On the subject of this gauge, two very important points must be made. It must never be forgotten or left unexplained, that this



Centreless grinder, gauge-controlled.

Fig. 6

is not an inspection instrument. Measurements made on it are made by the machine operator and used, either to put the size of the part in the centre of the tolerance, or else to watch and offset the effects of tool or wheel wear as outlined earlier, using the comparator (*Fig. 4*) on the machine.

This recommendation is in fact, of primary importance. Measurement of the part here is not, as with inspection, an end in itself, but is the intermediate operation required to be able to maintain the machine setting inside the tolerance limits.

Unless this policy is adhered to, it becomes difficult to ensure proper use is made of the comparators on the machine.

Next, the Production Gauge should not be confused with a continuous sizing device, even if the former is of a type taken to the work without removing the component from the machine. Measurement should be made with the machine stopped, either after finishing, when on a run, or else before taking the final cut, on a one-off job.

The comparators on the machine may be used in various ways, according to the work to be done.

There are three headings under which these applications may be grouped.

1st. Feed Gauge

Here the comparator is so placed as to show with the accuracy required the value of movements of, say, the wheel head, in the zone of finishing of the part. Examples have been given in the foregoing showing the actual usage in the commonest type of case, viz. cylindrical grinding.

The role of the Feed Gauge is a double one as stated, to centre the dispersion inside the tolerance limits, and to limit as far as possible the spread of this dispersion, to the point of making it negligible for a good machine and set-up.

It is used, therefore, either to add the cut shown by the Production Gauge to be required, or else as a " stop " on production runs.

The suppression of the effects of dispersion simplifies the surveillance required for the machine—this being largely confined to off-setting wheel, or tool, wear.

An important error is frequently made when using a Feed Gauge: often it is expected to give the size of the part. Explanations already given, largely on the score of the importance of evaluating inherent dispersion, show why this is not the case. It is the Production Gauge, placed beside or on the machine for the operator, which gives information on the size of the part.

According to the machining method, number of parts in the run, rate of tool-wear and so on, measurements will be taken at shorter or longer intervals. Experience very soon shows how long these intervals can be made in individual cases.

This is why the combination of Feed Gauge and Production Gauge constitutes a sort of running Quality Control Chart. It is obvious that the idea behind Machine Control is in exactly the same spirit as Quality Control, if developed a little differently.

The two systems are complementary. Quality Control deals with mass-production and medium accuracy—and particularly where operator intervention does not occur over long periods, as on automatics. Machine Control covers the high precision jobs not provided for in practice by Quality Control, or sometimes not economically possible under Q.C.

It is at this stage a little difficult to foresee what will eventually be formulated as statistical control when comparators are very widely used in the way outlined. That is, the finalised line (so far as such things can be finalised) on which the full system of Machine Control will develop, is open to deliberation and empirical confirmation.

There are already two or three differing methods being used to take advantage of the possibilities, and Inspectors—who mostly have experience of Quality Control nowadays—can visualise not only a simplification of that method, but extended use of such simplication.

The example previously given of a cylindrical grinder covers most cases of this type of machining. (*Fig. 6* shows the same basic idea applied to a centreless grinder).

The job here is through grinding of gudgeon pins 11 mm. diameter to 5 microns (·0002 in.). In the background is the Production Gauge, a light comparator with vee table to check for triangular lobing. The machine itself is fitted with a Feed Gauge—the comparator unit being fitted in an extension tube to bridge the gulf, and allow mounting in the best position.

Parts are delivered by the machine into the operator's hand for checking on the light vertical comparator—the workman being seated by the machine and not having to move to receive the part from it.

Initial setting of the machine is made as before, by using the first part, measuring it on the Production Gauge and using the Feed Gauge to manipulate the infeed wheel of the amount required—using "zero" on the graduated scale against the Feed Gauge manometer, for nominal size.

While machining of the run of parts proceeds, the operator watches the column of the Feed Gauge to check its immobility—any fluctuations of too great an importance are an immediate indication that the set-up is not capable of producing the precision required. This is the simplest example of a Feed Gauge showing inherent dispersion.

In the example under review, the cut taken is kept light, as this is necessary to obtain sufficient accuracy. Wheel wear is therefore low, and the operator only checks one in ten parts. As the size of each tenth part gradually rises, the wheel position is adjusted to recentre in the tolerance, without stopping the machine. Again there is no inspection as such, the finished parts going straight to the assembly line.

Another use of Feed Gauges—actual applications are very diverse—is on milling machines. Milling is an operation which for high accuracy, often has a bad reputation. There are complaints of lack of flexibility, low output and a need for highly skilled labour for even only medium accuracy. Mass-production milling overcomes these inconveniences, largely by using a great degree of simplification, but in small or medium-sized factories a classic type milling machine is still indispensable, and comparators can be a big help in its use.

About the biggest difficulty in milling is the determination of co-ordinates—a problem general to all machines including a system of setting on them.

Here the Feed Gauges, which may number five or six on one machine, may even be used with Production Gauges which are simple in the extreme. Although accuracy of the results depends on the accuracy of the Production Gauge, such a use of Feed Gauges will simplify the work often to a sufficient extent to allow unskilled operators to be used.

Application of Feed Gauges to surface grinders can readily be realised, and there are many other types of use—(*Figs. 7 and 8*) down to becoming practically an extensometer, for example, on the frame or legs of a rolling mill.

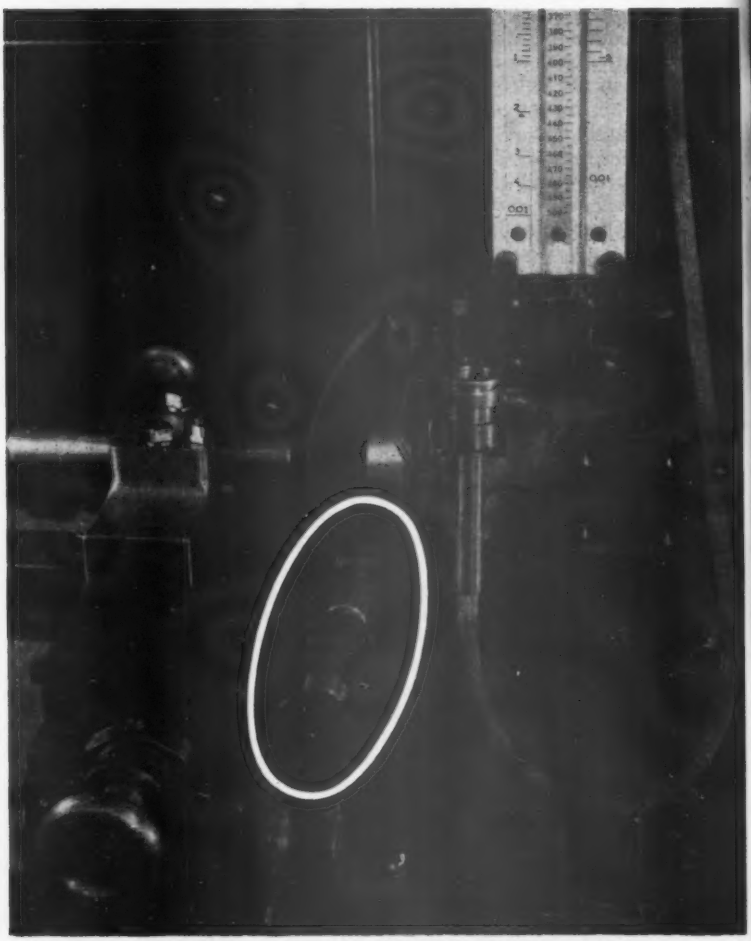
2nd. Calliper Gauges

Having previously stated that the Arnold type gauge is only applicable to certain machine problems, to wit plunge grinding on centres or mandrel for production runs, it is however usually an obligatory solution when such a component is subject to any degree of bending—steadies or no.

It is unfortunate that in a number of cases this solution is not admissible since parts of much flexibility are, for example, often so long that traversing cuts have to be made. Here the Calliper Gauge is not usually so successful.

Actually, examining a Calliper Gauge through the eyes of a metrologist it will be seen that every factor which could make it defective is united in it. However, the influence of the rotation of the part, and the presence of coolant allow the contacts of the gauge to slide adequately, and are conducive to the gauge assuming a properly perpendicular position to the plane in which measurements

Fig. 7.



Feed Gauge and Production Gauge on semi-automatic lathe.

Fig. 8 ⟶

Rough and fine boring of small cylinder, gauge controlled. One operator to two machines.

must be made. So in spite of appearances, like the famous bumble-bee which is proven unable to fly, repeatability is very good with this type of gauge; so long as initial setting is accomplished with a reference piece in the machine, measured under the same conditions as the component will be, good results are obtained.

Here, perhaps even more than with a Feed Gauge, air-operation with its special characteristics shows to striking advantage. The non-linear character of the scale already discussed, seems to give even better results on form and surface finish. Resistance to shocks and vibration, and other factors have led to very large scale use being made of air-operated Calliper Gauges.

Details of results given by Messrs. Debos, Pommier and Tordais† show some remarkable results from the mere replacement of the clock on Calliper Gauges by an air-operated comparator unit.

One example at Messrs. Renault, France is on the grinding of crankshaft journals, where such modifications were made to Arnold type gauges.

The tolerance on the 760 c.c. engine crankshaft is ·0005 in. unilateral. The replacement of the dial gauge was with an air-operated comparator unit giving the usual type of non-linear scale produced for such cases, with magnification rising to $\times 5{,}000$ at "o."

Without altering production rate, rejects at once fell to practically nothing, and the cost of the installation was paid for in some 40 working hours, the value of improvement in form and finish not being taken into account in estimating this.

It is a point of interest in passing that it is usually found better not to show the tolerance of the part against the column of the Feed or Calliper Gauge. The nominal or "o" is boldly shown, and the operator works to this. This leads him not only to benefit to the full from the effect of the increasing magnification, but tends to make him aim at the centre of the tolerance, and lastly tends to avoid the manometer being merely glanced at instead of followed down with the eye.

The question of automatic sizing again occurs in conjunction with the use of Calliper Gauges—in this case usually meaning a device first to reduce rate of in-feed and next to stop the machine.

Of course, a Production Gauge is in any event necessary beside the machine, but where even only automatic stopping of the machine is incorporated in the Calliper the Production Gauge becomes indispensable. Accidental variations may otherwise lead to serious trouble, as this can affect a number of parts. The more complicated the automatic device the greater such risk of variation becomes.

The crux of the two points of view is the labour aspect, and opinions among impartial engineers vary widely enough to show that drawbacks do exist with the use of these automatic devices.

† Microtecnic (Lausanne) No. 6. Vol. V, 1951

We have ourselves been associated with some two or three differing types of automatic sizing devices and there is no doubt in our minds that the decision for or against can only be taken by the user himself.

3rd. Various Uses of Comparators for Production

It is not possible to go through all the applications but some of them are:—

Tool Setting Gauges, as already mentioned.

Comparators used to adjust out taper, or give a required taper.

Installation of comparators for accurate positioning of the component on or in the machine, depth stops for boring, and many others.

Some Points of Debate

Machine Control is effectively a radically different treatment of the whole psychology of production matters; it is not easy to grasp at once, without a practical demonstration of gauge-controlled machines and some personal experience of the extent in improvement in morale, quality and simplification.

That it is such a benefit for the machine operator to know exactly where he is at any given moment, that inspection as such can be removed from a very high precision, high output component, is hard to believe possible at once.

Normally in discussion of Machine Control with anyone who has not yet been able to consider the idea on his own, three main queries are always raised.

One has been dealt with in the foregoing, that is, comparing Feed Gauging with automatic sizing.

For the two others, experience has provided a valid answer.

For example, the system *is* of value for machines which are not of the very best precision and quality generally. Feed gauging is of interest as soon as tolerances get as small as ·002 in. The main ideas leading to the development of the gauges and applications in connection with the system were, in order of importance:—

(1) Reduction of rejects.

(2) Simplification in use of machine tool, i.e. increase in production rate.

(3) Reduction of Inspection costs and expenditure on instruments.

(4) Increase in precision.

(5) Use of unskilled labour on precision work.

(6) Evaluation of inherent machine dispersion,

and some very interesting figures from Messrs. Timken (France) bear out this contention: see table, *Fig. 9*.

Fig. 9

Machine used: Gendron 350 × 1,000 Universal Grinder.

Job: Cylindrical grinding of o.d. of outer races.

Sizes in millimetres.

Size of parts		Tolerances			Hourly production		Increase in production
O.D.	Width	Dia.	Ovality	Taper	Without M.C.	With M.C.	
170	37	·013 mm.	·0025 mm.	·0025 mm.	2·04	2·31	13·23%
150	30	·013 mm.	·0025 mm.	·0025 mm.	2·50	3·16	26·40%
120	24·23	·013 mm.	·0025 mm.	·0025 mm.	2·82	3·45	22·34%
120	24·25	·013 mm.	·0025 mm.	·0025 mm.	2·76	4·14	50·00%
112·71	23·81	·013 mm.	·0025 mm.	·0025 mm.	2·96	3·92	32·43%
93·26	23·81	·013 mm.	·0025 mm.	·0025 mm.	2·84	3·45	21·47%

Average increase in production: 28·32%.

Rejects fell from 6·88% to 4·35% = 36·77% drop in number of rejects.

Figures given were taken over a period of:
6 months without Machine Control.
12 months with Machine Control.

1948/49

Increase in precision occupies fourth place only. In fact, the results in this sphere seem automatically so good, that it becomes secondary in importance from the gauge development point of view.

The better the machine, the greater degree of precision is naturally arrived at—but not necessarily the greater degree of improvement.

Another point of discussion is whether or not the " reliance " apparently placed in the machine operator is too great. This is a basic query, affecting as it does the validity of the entire system of Machine Control.

Apart from actual experience which proves the point to be in practice quite acceptable, perhaps the best illustration is by allegory. If the machine operator were to be in the position of a man attempting to throw components into a small box from thirty feet away, it would be reasonable to suppose he would score a number of misses. If, however, the box were a large one, and right under his hand, it would almost be more of an effort to miss.

The Feed Gauge plays the part of placing the tolerance under the operator's hand, and the high magnification of the size indications increases the dimensions of the tolerance from the operator's point of view.

It is, in fact, more of an effort for the operator to produce the wrong size than to produce the right one and, when the dispersion/tolerance ratio approaches unity, it is usually the machine operator who gives warning by rightly complaining of his work becoming too difficult.

Conclusions In Machine Control there is a very important possibility of making an overall step forward in precision engineering methods and factory organisation.

The system is not a straight development of existing methods accepted as classic, but rather is a swiftly developed answer drawn from another turning from the earlier cross-roads at which the road to the now " classic " layout of Inspection was, in fact, followed.

Metrology should be largely employed in finding aids for production, and for machining particularly. This is an enormous field of activity which as yet is only partly explored.

The concentration on putting gauges to work in order to avoid rejects, instead of to discover them after it is too late, and the consequent practical application and consideration of gauges as part of a machining operation, leads to a radical change in outlook of the whole factory.

Machine Control is no mere theory; it has been widely tried and has proven its worth, even when the very best use is not made of the possibilities allowed by it.

Real progress can only be made when the machine operator can see what he is doing. The proper function of metrology is to allow this, by extending and sharpening his perceptions. The gauge designer must consider himself, and be considered, the ally of the Production Department at all times.

GENERAL MEETING of the INSTITUTION

London, 3rd July, 1952

THE President of the Institution, Sir Cecil Weir, K.C.M.G., K.B.E., M.C., D.L., presided at a General Meeting of the Institution held at the Royal Empire Society, London, on 3rd July, 1952.

Opening the proceedings the President said that his first duty was to introduce himself, as it was the first Meeting of the Institution which he had attended in his official capacity. He felt greatly honoured that he should have been invited to accept what he considered to be the very important position of President of such a fine Institution. It was also gratifying that the first meeting which he attended as President should prove to him how great was the interest taken by members of the Institution in modern developments. He realised that he had started a year—it might be a little more—of hard labour, because the President of the Institution of Production Engineers was expected and would wish to make his contribution to the work of that body ; but he knew he would find it very agreeable and educative.

In fact, his education was beginning right away, and he desired on behalf of the members to extend a very warm welcome to the two authors of the very interesting paper on "Machine Control—The Use of Comparators for Production," Mr. J. D. Richards and Mr. R. Yribarren.

Introducing the Authors

Mr. Yribarren was born in Bayonne and educated in France, in which country he had spent most of his life. He joined Solex in 1931 as a boy in the carburettor service station, and was still with the organisation. The first twelve years of his service with the company was spent in going through the various departments of the business. Mr. Yribarren had specialised in the development of air gauges and, whilst he was a prisoner-of-war in Germany, during the last war, he made a concentrated study of metrology.

In 1944, a company called the " Société d'Application de Metrologie Industrielle " was formed in France and was mainly concerned with the large scale manufacture of air gauges. Mr. Yribarren, as General Manager of that company, was given the responsibility of launching the project and strengthening the international gauging organisation, operating in a number of countries.

He was the author of a number of papers on the subject of machine control and was, as one might imagine, a strong and

convinced believer in the use of gauges as aids to production rather than merely for checking measurements. His papers had been presented in many parts of the Continent, but it was the first occasion on which Mr. Yribarren had taken part in a discussion before an English audience. It was particularly pleasing that he should have such a fine audience, and the President could assure him, knowing many of the people present, that, in the engineering industry, it was a very distinguished audience. There were people present from a large number of associations as well as from a great many of the best known firms in this country. Mr. Yribarren's previous papers had been presented in Stockholm, Milan, Turin, Paris, Zurich, Brussels, Barcelona and Lisbon, and he was a very great authority on the subject.

Mr. Douglas Richards was a director in the Solex group. He was educated at Marlborough, and went straight from school into the British Solex Gauge Experimental Department whilst awaiting his call-up as a member of the R.A.F. Reserve. The next four years he spent first in the Experimental Department and later undergoing technical training on the bench, and he was subsequently appointed assistant to the Chief Engineer. During that time he transferred to the Fleet Air Arm Reserve.

Since 1947 he had acted as assistant to the Managing Director of all the companies in the British Solex organisation and had himself been appointed to the Board of Directors.

Tribute to Mr. Puckey

Before calling on Mr. Richards to present the Paper, the President said he was very glad that Mr. Walter C. Puckey, Deputy Controller of Supplies (Air), Ministry of Supply, was present, and he desired to express his appreciation and, he felt sure, that of all the members of the Institution, for the wonderful work which Mr. Puckey had done as Chairman of the Institution of Production Engineers.

As to the subject matter of the Paper, probably everyone realised the importance of machine control. Everyone recognised the great importance of trying to reduce the number of rejects on inspection and, indeed, of making the job of inspection, which was so very important, a great deal easier and a great deal less expensive to the companies which had to have large inspection departments.

Mr. J. D. Richards, presenting the Paper which appears on pages 447/474, said that it was a little difficult to write a Paper on machine control because it was not a subject which dealt with facts and figures. The results of experiments could not be recounted in detail nor could any concrete information be given. The object of the Paper was to try and put over an idea, to put over an outlook, particularly in regard to gauging instruments, which was not based on anything existing at the present time. It was stated towards the end of the Paper—in a mixed metaphor !—that

it was drawn from an earlier state of affairs, that is to say, when measuring instruments were first used by, and first produced for, the machine operator. Therefore it was rather difficult, on first acquaintance with the subject, to grasp at once exactly what the differences were in outlook, what exactly were the implications in the use of the system, and what advantages could be derived from it.

Development of Measuring Instruments

Since the first division was made between Inspection and Production—when the first measuring instruments were put into the hands of somebody who was not actually using them to help him produce the job—the design and development of measuring instruments had been moving towards perfection with the idea of putting them at the service of inspection. In other words, the job of Inspection had become, other things being equal, more and more easy by virtue of the instruments which had been placed at the disposal of inspectors. On the other hand, things on the Production side had become correspondingly more and more difficult; demands were being made to produce to tighter tolerances all the time; Production was being asked to use a higher percentage of unskilled labour and, unlike Inspection, did not possess the same means of knowing where it was or what it was doing.

There was a certain amount of what one might call " fear " on the part of the Production side in respect of the work of the Inspection Department, and it was only when Production wanted indulgence from Inspection that it tended to ask for help from the latter. In other words, Production did not go to Inspection to ask for help on machining problems, or for assistance in producing better parts. It went to Inspection usually to ask for help in exercising its discretion and there had, in fact, been in this country during the last war a number of gentlemen known as " quality engineers " who had powers to override the black and white findings of the Inspection Department. These were not part of organisation generally, but existed in many big and good factories.

The inference was that if parts were acceptable outside tolerance limits, the limits at which they were rejected were probably too close. But the inference was also that some other agency was needed to help the Production side, based on the findings and the figures available to Inspection.

The Toolmakers' Reaction

When the idea of machine control came to be considered very seriously and came, moreover, to be presented to individual engineers in industry—the people who would use it—it was very important to realise that there were two types of people who should devote their energy and brains to developing the idea.

There were present, he was pleased to see, members of both the M.T.T.A. and the G.T.M.A. who were, in point of fact, two of the most important bodies in industry for the development and acceptance of the idea of machine control. It depended on the machine tool manufacturer very largely whether the idea was fruitful, accepted by the users, and whether it was accepted as being something normal. Opposition from machine tool manufacturers was very difficult to overcome in the face of the normal, initial, psychological reaction of the workmen who were asked to go on to machine control. It was a very curious fact that in practice it was the unskilled workers who jumped at machine control, who liked it and who very often, after experience, asked for it. It was the more skilled man who often believed that the system robbed him of some of his professional qualifications. In fact, that was not true.

Machine control should be looked upon in this question with the idea of feed gauging only, which was the basic application of a measuring instrument on the machine to enable the operator to translate the size of the part found, into suitable manipulation of the machine tool. It was a system which materialised the inherent dispersion of the machine. This was a factor outside what might be called the normal human perception which a skilled operator could use because he knew his machine. It was found, after the system had been properly tried, and if the people responsible for putting it into operation had one or two of the points raised in the Paper clearly in mind, (in particular that these gauges were not inspection instruments but were part of the equipment of the machines and part of the machining process), that the professional qualifications even of a highly skilled man were improved by machine control.

That was mentioned somewhat at length in order to show the importance of the machine tool manufacturer understanding the aim of putting those instruments on the machines. It was not always easy to ask him to do it because it readily showed up inherent dispersion in the machine. Experience showed that even on new machines of very good makes there was a good deal more inherent dispersion than one might have believed. It was important that the machine manufacturer should know exactly what the idea of machine control was, so that he could help to get the idea put over.

The purpose of the Paper was really to encourage both Production and Inspection to consider each other as allies helping to solve the problems of production. When one had grown up with an idea which was radically different, it was difficult to ask somebody to accept it at once.

The other purpose of the Paper was to encourage the gauge makers and gauge designers to put more of their energy and time into producing instruments for that purpose, rather than for the purpose of putting them at the disposal of Inspection.

The Need for Metrology

There were three real origins for the need for metrology, one of which was that of accuracy, because of the need for some amplification method to enable the operator to extend his powers beyond those of which he was capable unaided. The second was the problem of unskilled labour. That did not appear to be a problem which necessarily required metrology, but it was so because unskilled labour had no idea of the problem or even the meaning of .0001 in. In fact, there were many different ideas as to its meaning. To many people it meant the difference in two divisions on a clock gauge, to many other people it meant something else, but to unskilled labour it did not mean very much at all. The third origin of metrology was the incidence of rejects. It was contended that this really became noticeable when the ratio between the tolerance on the part and the inherent dispersion of the machine approached unity.

The biggest factor for metrology in solving all three of those problems was always high magnification. In all three cases, in fact, magnification served the purpose of widening the walls of the room, if it could be put in that way. There was more room to move inside high magnification. To obtain the results normally found with machine control, the starting point should be the mere application of a Production Gauge and of a Feed Gauge to a machine.

There was a tendency in the Paper to go to a further stage of development of machine control than was possible in this country at the present time. It had been running on the Continent to an increasing degree for a matter of five or six years and there were Production Engineers who had experience of it over a period of five years, on their own production problems. They were obviously more at home with it and had time to develop it further. But if the Feed Gauge and Production Gauge idea were adopted, the remaining after-possibilities which were mentioned did become obvious. The mere use of gauging instruments in that way often had the effect, for example, of reducing the reject level to the point at which inspection had no worries or troubles on the score of articles produced from a gauge-controlled machine; other possibilities followed in the same way.

There was perhaps another point which could be made on the score of high magnification and the idea of feed gauging, namely, measuring the movement or indicating the position of the machine slides which was, of course, basically nothing new. Clock gauges had been used for years, for example, on milling machines, and there might be some question why the system of feed gauges was in any way different from the clock gauge; the answer came back to magnification.

The effects obtained from the non-linear scale which had been

used up to the present time on feed gauging, and the effects of the high magnification as zero was approached were outlined. They were to make the operator progressively slow down the rate of infeed and finish with practically no pressure on the part. There were figures available of the effects on surface finish and on form. Both were extremely good and both were obtainable only with difficulty by any other method.

It was appreciated that a new job for Inspection was outlined in the Paper which appeared to be rather different from that which existed at present. It was true that the Paper tended, perhaps, to over-emphasise the point being made, and it was realised that it was not possible in almost all cases to abolish the Inspection Department; but it was suggested that it was possible for the Inspection Department to become an active aid to production and, if necessary, to be described by a different title, because that always made new ideas more acceptable. The title might possibly be that of " Quality Engineers."

Recently there had been quite a lot of interest taken in preventive maintenance on machines and under the system of machine control, preventive maintenance was easily dealt with. Again, in a large scale production factory, space requirements were very important, and there were the difficulties of having alternative machine tools for the job and extra space for the work to be carried out at short notice should a machine break down without warning. The preventive maintenance allowed by machine control afforded a good opportunity to make preparations in advance for taking the machine out of service before its dispersion ratio had ever reached anything like unity with the tolerance imposed.

DISCUSSION

Mr. Dormer (*Ministry of Supply*), in opening the discussion, said that his first duty was to apologise on behalf of Mr. S. W. Rawson, the Director-General of Machine Tools, Ministry of Supply, for his inability to be present. He had intended to be present and open the discussion but, unfortunately, he was called away.

The gauge and tool section of the engineering industry was a problem child. Sometimes it was asked to perform absolute wonders and at other times it was so neglected that the N.S.P.C.C. might well be called in! In times of rearmament the demand for gauges, special fixtures, etc., placed an overwhelming burden on the industry. So far all developments in gauging had been along traditional lines; material was gauged in a machine and by inspectors. Recently, however, he had been privileged to see an entirely new approach to the problem, the Solex control system.

Briefly that system placed more responsibility on the workman than hitherto, and it enabled him to control an intricate machine with less skill than before and to maintain the accuracy of the product. That which had been heard already might well persuade many to consider departing from the traditional lines and adopting some such system as had been outlined by the authors. That would have a two-fold advantage inasmuch as, first, the call for traditional gauges would not be so heavily stressed in times of rearmament, and, second, the workmen would be in a position to turn out more accurate parts with consistency, and the number of rejected parts would thereby be lessened. That was what the industry was looking for. The great scramble to try and persuade somebody to make something more intricate than he had ever made before was putting many grey hairs on his head as well as on those of other members of his department!

Mr. J. Loxham (Managing Director, *Sigma Instrument Company*) said that the technique outlined in the Paper gave the machine operator or the Patrol Inspector the means whereby he could see two important features in a production process. The first was that proportion of the tolerance which was used by inaccuracies in the machine. The magnitude of this feature could be measured, for instance, on a five-spindle automatic lathe by taking ten pieces, produced consecutively, measuring them on a particular dimension and noting the spread of size in the small batch. The magnitude of the spread of size should not exceed 30 per cent. of the total working tolerance. If it was larger than this amount the machine operator was being asked to undertake a task which was very difficult, very wasteful and, in consequence, very unprofitable. The second feature was that of being able to observe the movement of mean size inside a tolerance boundary. It was likely that in future years there would be great developments in the technically very sound technique of giving the person in control of the manufacturing process, the means whereby he could observe by measurement changes these two important features of the production process.

The new technique was a logical step in the development of an efficient system of engineering production, and any effort expended in studying the application of this new system to the control of quality of mass produced engineering parts was likely to give very good results.

The Paper described one particular system of air gauging. There were other systems of air gauging and, in addition, he thought the authors would agree that certain inspection problems could best be solved by mechanical comparators, electrical comparators, optical comparators or optical projection. Therefore, the important part of the Paper would appear to be the exposition of a technique.

He could not give quite the same support to some of the practical applications cited. For example, Fig. 5 showed a means for setting a tool in a boring bar. That operation was a very simple one, and probably more than half those present knew that in Britain a device consisting of a " V " block with a micrometer mounted at right angles to it had been used for many years. The " V " block was placed on the boring bar, the micrometer was adjusted and the results read. That was a much simpler and completely satisfactory system.

Reference was made to the benefit of a non-linear scale, but with respect he suggested that the authors should have referred to the disadvantages of a non-linear scale, for it would not be true to say that there was none. The majority of cases quoted in the Paper referred to machine control of grinding machines, and some of them were very good and deserved very careful study. It would be interesting to know whether the authors had any experience such as controlling the quality of a small brass fuse cap about $\frac{3}{8}$ in. diameter by $\frac{1}{2}$ in. long, and requiring control of nine separate dimensions and including outside and inside diameter, external and internal lengths. The part to be made on a five-spindle lathe which, during the metal cutting period of the operation, would be flooded with oil. Had the system been used for the control of such operations? That type of operation was fundamentally different from that of controlling a grinding machine where one dimension only was under consideration and the cutting medium, in the form of a grinding wheel, was subject to rapid wear. In addition, in the control of grinding machines by the method described in the Paper the operator controlled the size while the operation was in progress. On the five-spindle automatic lathe the setter set the machine, he then made a part and when the manufacturing process on that particular part was completed he measured the part. He could not control the machine during the manufacturing process; there was no mechanism provided with which he could do this.

It was suggested that one of the uses of the fully automatic Inspection Machine was to place such a machine near the manufacturing machine and in that way, it would act partially as a means of machine control. As the person responsible for the conception, development, manufacture and supply of a fair number of these machines, Mr. Loxham desired to point out that he had not that idea in mind. The original use, and he still believed the best use, of an automatic machine was to remove the few faulty parts which it was thought might be present in a quantity of finished parts.

In his view, the most important service which inspection could and should render to production was to help to control the manufacturing process. The technique described in the Paper was one method, but there were others. Some production processes were

of a type which could be controlled so well that there was no need for a fully automatic machine, or any other system of one hundred per cent. final inspection to be used. There were other processes where, if they were run at the most efficient operating speeds, some faulty parts were inevitable. If the quantities produced were large and it was desirable to remove the faulty parts from the bulk, some form of mechanised inspection was usually the most efficient way of carrying out the operation.

With regard to the use of unskilled operators, Mr. Loxham very much deprecated the fact that in this country it was claimed to be necessary to make manufacturing processes so simple that any fool could do them. This was not sound long-term planning, particularly when such vast sums of money were being spent on educating the younger generation. If great care was not exercised, we should spend our efforts developing a technique which semi-civilised countries, whose standard of living was much lower than that demanded by the British worker, could copy to their considerable gain and to our grievous loss. He submitted that by the use of techniques of the type described in the Paper, which would give accurate technical information of a kind which was not available when the operator was supplied with fixed anvil type gauges, it was possible to increase speeds and feeds and observe the minute effect of such changes made in the quantity of the parts produced. By the use of highly skilled operators using instruments to control the complicated manufacturing process, it was possible to produce by mass production methods articles of quality which were superior to the fine hand-made products about which far too much was said. The welfare of the engineering industry of this country depended to a large extent upon the ability to combine all the benefits of mass production, complex mechanisation, machine control by use of direct indicating or recording instruments, highly skilled planning engineers and finally and very important, highly skilled machine operators.

Production engineering as carried out in this country at the present time could not be classified as a science. Hazleton used to say to the speaker, " Loxham, what can we do to make production engineering a science ? " and the reply which Mr. Loxham gave to that question fifteen years ago he repeated in present times. It was that a start should be made to measure the things produced. When once a start was made on measuring the things produced, it was possible to observe the nature of the process and to do something to control the process as a result of that measurement. This constituted approaching a production engineering problem in a scientific manner. He asked the President, in his high office, to do everything he could to elevate the influence of production engineering. It could be done and the Paper was a valuable contribution in that direction.

Mr. Hessen (*Ministry of Supply*) said that he found the Paper very interesting, particularly as he had had the privilege of seeing the system in operation in France and, at the same time, had some practical experience of trying to set it up in the Tool Room over which he had jurisdiction.

Mr. Dormer had already pointed out that in times of rearmament, the gauge-making industry had no chance to help anyone else when coping with the order on which it was engaged ; in peacetime, however, there was plenty of opportunity of taking every order which came along. In his position, he had to get the gauges which were so necessary for a branch of the Ministry of Supply to control the contracts which were placed, and in many instances this was very difficult.

The gauging policy had been changed as a result of the experiences which were gained at the cessation of hostilities, when it was found that the Ministry of Supply Inspectorates had a large number of gauges which were used for final inspection work, as well as a second lot of similar gauges used by the contractors. The problem had been studied very carefully and there had been a departure to a great extent from the policy of fixed gauges, in favour of application of experience in measurement as suggested by Mr. Loxham. There was no doubt that if components could be measured it would assist production.

The days had gone when the Inspection Departments simply picked up an article and rejected it. Industry prided itself on the fact that Inspection Departments did not act that way, but could pick out an article and say : "This is wrong and we can tell you by how much." This was a very valuable departure from the past, which had to be borne in mind by everybody.

He did not entirely agree with Mr. Richards when he said that the relationship between Production and Inspection was on the original basis. Perhaps he misunderstood him. Those days had gone and would probably never come back. At the same time, the question of machine control could not be ignored on the grounds that because an unskilled individual could operate a complicated machine, the inference was that this country would be driven to ruination. In Mr. Hessen's view this was incorrect, particularly if the country was facing a period of tension or—God forbid—a war. Then every person, however little mechanical experience he or she might have, had to turn the handles and produce the equipment required. From that point of view, we had to bear in mind that it would be our task to encourage the use of unskilled labour.

There were machines that could produce articles in their millions—some of them good and some of them bad—and some of these articles had to go into components which had lethal ends,

such as explosives; one could not absolutely rely on any form of control except one hundred per cent. inspection. A component which was slightly outside its tolerances might cause death to one or a dozen men, and any reasonable person would not expect a soldier to take such a risk unless there was a hundred per cent. assurance.

By the use of Machine Control and the conventional inspection method, merged together, probably better results could be obtained. It was generally recognised that inspection was an overhead. It was also true to say that any inspection which was carried out purely for inspection's sake was wasteful. If a system could be employed which would cut down the Inspection Departments (the system described might produce that result), then everyone was bound to pay as much attention to it as possible, as this would naturally improve production and reduce production costs.

Mr. Mark H. Taylor (Managing Director, *Taylor, Taylor & Hobson, Ltd.*) said that he had had experience over at least ten years of practising the general principles which were outlined in the excellent Paper; but in his view it skipped very lightly over the most important aspect of the whole subject, namely, the psychological aspect.

In industry there had been a tendency to overwork the people at the top with technical problems, and to expect them to use their brains and not their hands, and to give an opportunity to the machine minders to use their hands only and not their brains. It would seem that if the desired degree of productivity were to be achieved, it was necessary to make sure that there was enthusiasm at all levels. Nobody was enthusiastic, however, unless he were given an opportunity of using his brain to the maximum extent of which he was capable. The machine operator must be given an opportunity of using his brain, and be allowed to feel that when he had done a good job, it had been done well because he had personally contributed something.

The general scheme as outlined in the Paper afforded an opportunity of giving to the operator at all levels the chance of contributing his own brain power to the performance of the operation which he undertook. Could the man in the shop, equipped with less efficient means than the inspectorate, be enthusiastic? He should be given the means—not necessarily the same—whereby he could say with certainty : " I know that piece is going to be passed." The complaint was made that there was so much unskilled labour. Was that really the fault of labour or was it because it had not been given an opportunity of becoming skilled? The Paper, if followed up, would make a great contribution to the nation's productivity.

Mr. Shilstone (*Inspectorate of Armaments*) said that he had listened with great interest to the presentation of the Paper and the discussion, and was interested to know that an attempt was being made

to concentrate on quality at the point of production. The Inspectorate of Armaments used, during the war, to devote most of its time and energies to sorting out bad work from good. As had already been pointed out, the problem of sorting good articles from bad by human labour was expensive and not very efficient. In fact, various experiments which had been carried out had proved that by hand sorting or continuous examination, not more than 97 or 98 per cent. efficiency could be expected; in fact, the figure was sometimes even lower.

Direct measurement at the point of production or where the job was actually produced would, in his view, be the best possible method, because not only did it save scrap, but it also reduced inspection costs and ensured quality. Moreover it provided some degree of responsibility and interest to the operator.

Good inspection from the customer acceptance point of view—in which the Inspectorate of Armaments was interested—depended not on inspecting a job as much as possible, but as little as possible consistent with safety, strength, functioning and interchangeability. The Inspectorate was prepared to make use of contractors' inspection systems, bearing in mind always that there were two separate and distinct responsibilities involved—the responsibility of the contractor to produce satisfactorily to drawings and specifications, and the responsibility of the Inspectorate to accept the article from the point of view of safety, functioning, strength and interchangeability. Where possible the Inspectorate was prepared to combine those two responsibilities early in the production line, provided the contractor was able to give the necessary facilities, and prove that the method was satisfactory. The Inspectorate had its own gauging department which could investigate the system from the point of view of accuracy of measurement.

There were however, snags in the use of such methods. For instance, one operation carried out early on in the production sequence might be upset by a subsequent operation. A turning operation might be correctly carried out, but subsequently a boring operation might spread the job. In the manufacture of a shell, the banding operation might cause the walls of the shell to cave in. It followed, therefore, that if the acceptance/inspection operations were arranged to take place early in the production line, care had to be exercised on the way they were done and where they were done.

Another point which had not been considered was the attitude of Trades Unions to this question. As soon as a start was made on measuring, the Trades Unions stepped in and contended that if a man was engaged on measuring then he must be skilled. That was rather a narrow outlook in his view, and some action seemed necessary with the Trades Unions, to enable intelligent workers to

have the opportunity of accepting greater responsibility in contributing towards improvement in quality of production. Simply because a person measured something it was surely not necessary for him to have gone through a complete course of five years practical training.

Mr. Yribarren said that the first time he heard some interesting things about machine control was in London one year after the war. It had come as a surprise to those in France to learn that the industry in Britain had studied the use of quality control to such an extent. A lot more had been written than had been done about quality control which, in his view, was the first idea of machine control. It was because of quality control that it had been possible to understand the problems of machine tools. That meant, of course, the problem of dispersion.

Quality control was very useful for automatic presses, diecasting and things like that, but it was not possible to extend quality control to all purposes. For example, in order to do an accurate job with the grinding machine the control chart was not sufficient. The method was too dangerous, and in his view it was necessary to use another method which put something between the chart and the machine.

He was happy to have the opportunity of expressing gratitude to British colleagues for having given some very good ideas and for helping the industry in France to improve their conditions of production.

Mr. W. J. Swift (Assistant Director of Engineers' Cutting Tools and Gauges, *Ministry of Supply*) said he recalled that in the First World War there was a shortage of shells in France. The main reason for that position was due to the lack of Production Gauges which, with the method then employed in the production of shells, was essential.

In those days parent schemes were extremely popular, special plant was not available and, for the most part, shells were produced on various standard types of machine tools, or on those which could be adapted. The parent company with whom the contract was placed used sub-contractors in their locality to do certain operations for which they had not the facilities in their own works. That meant that one sub-contractor, after completing an operation, would pass the partly machined shell on to another contractor, and so on, until it was returned to the main contractor for finishing. It would readily be understood that such a method required a complete control on the dimensional accuracy during the operations, for which large quantities of gauges were needed for checking the components in the various stages of production. The gauges were not there. To provide the necessary gauges, the Ministry of

Munitions then set up a Gauge Department to design and produce sufficient gauges to meet the level required, and when that was done, the shell problem disappeared.

Before the Second World War commenced, the capacity to meet the potential requirements of gauges was again inadequate, and a question was raised in the House if preparations were in hand to ensure a sufficiency of gauges, in the event of war. Action was taken by the Government to remedy the position and before the war commenced considerable additional capacity was provided and actually being used. Although those measures were taken some two or three years before the war commenced, there was always a struggle to get the more difficult types, and it was probably true to say that that position still obtained. The basic cause of that was due principally to the lack of sufficient experienced skilled men able to make intricate and very fine limit gauges.

He had mentioned those historical facts to bring into prominence the necessity for reducing the demand for gauges, particularly in war time, to the least possible amount. It did appear that the system described by the authors of the Paper would reduce the call for gauges, although it would not affect the demand for the receiver and other kindred types to any extent. Not only did gauges require skilled craftsmen to make them, but also skilled inspectors were needed to check them and, of course, very expensive capital equipment was also needed. It was reasonable to say that, if the demand for the general run of gauges could be reduced, an opportunity presented itself for the gauge making industry to concentrate their talents on the more difficult types. The manufacture of the equipment associated with the machine control system under discussion did not require the high degree of skill associated with gauges, except for the manufacture of the check gauges. It was pleasing to know that the comparators required little maintenance as opposed to the constant care and attention which had to be given to the orthodox gauges.

In his opinion—and speaking from the gauging angle principally—the system should ease considerably the problem of obtaining and maintaining gauges of the orthodox type which had existed for about forty years. He had seen the system working in three factories in France with very satisfactory results. He was amazed to see small petrol engines being produced on controlled machines without any of the parts being inspected before assembly. Apart from the saving of inspection labour, there was also a saving of machine setters.

It was imperative that efforts were made to produce more economically to meet foreign competition in peace time for the world markets, and in war time it was essential to use manpower

to the best advantage. It was in the system under discussion that there was clearly a possibility of employing less indirect labour without any loss in quality of production.

In conclusion Mr. Swift said he felt rather a Dr. Jekyll and Mr. Hyde, in view of the fact that only a few months ago he was partly responsible for initiating a small exhibition of multi-gauge machines. He had great faith in the part which multi-gauge machines could play, but probably the answer might be found in some combination of the two systems to obtain the best results.

Mr. W. S. Hollis (Assistant Director, Aircraft Production (Development), *Ministry of Supply*) stated that it would appear the system offered two applications, one from the point of view of normal production where such a device was capable of being pre-set to produce finished dimensions, and the other from the point of view of the really skilled man who had to grind to a set diameter and explore his work subsequently. It would offer considerable advantage in the latter case so far as grinding allowances were concerned in that the man could adjust his speed of approach, thus quickly removing the boundary stock to the point where he was nearing the final dimensions, thus expeditiously finishing the job. Equipment of the type under discussion would also be a great advantage for small production runs in that respect.

The Paper dealt exclusively with air gauging, and no reference was made to any means of electronic dimension, such as were being investigated by a few people in this country and which employed comparators operating like a Vernier scale, on which there might be some 10,000 lines to the inch. It would be useful if the authors looked further into these systems and gave the benefit of their observations at a later date.

Mr. Richards, in reply, said that it might perhaps have been made clearer in the Paper, particularly in the section which dealt with automatic inspection, that close tolerance parts were being referred to rather than wide tolerance parts. The systems of machine control and quality control were fully complementary. It would not be found that the jobs best done by quality control could really be tackled by machine control. There was no doubt at all that quality control was the method with wide tolerances, and that obviously in view of the tolerances on the parts being produced in the case mentioned by Mr. Loxham, automatic inspection was the way of checking them. It was not the authors' intention to go further than to say that for close tolerance parts the problem could be better solved by machine control. On page 466 that was more or less stated, but it might have been better if the distinction had been drawn more clearly.

Perhaps the most important point which had been raised was the question of psychology, and that came back to the question of

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whether machine control improved or reduced the operator's skill. One could not stop progress. It was no good failing to follow up a line of development because of any fear of what use somebody else might make of it. In fact, machine control increased skill because unskilled labour was a term which perhaps tended to mean something different from what it really was. An unskilled operator of a machine was merely unskilled in the use of machine tools. He was not unskilled in crossing the street, and if he could be given an implement which increased his skill in manipulating a machine, his skill was not being reduced. In fact, the facilities were being improved. The man was being given the possibility of crossing that which had been compared to the sound barrier, and appreciating with very great ease variations in dimensions which he could not visualise in any other way.

With regard to the tool setting gauge described in Fig. 5 that was, of course, nothing new at all. The only important thing about the type of tool-setting gauge which was described (it could be achieved by many different methods but the authors used air operation because they happened to know it) was magnification. With small magnification it was not so easy to see the position, but with large magnification operators who were " unskilled " worked to very close tolerances without even knowing that they were doing so. The same thing occurred with inherent dispersion. When a machine was controlled the operator himself could state at any time the inherent dispersion of his machine to within a half or a tenth. He did not describe it in that way. He said that the machine gauge did not agree with the production gauge at the side of the machine by three divisions on the scale. This was significant insofar as it meant that the operator was unaware of what the divisions represented. That was not a drawback. Many were unaware of what certain measurements represented. They were compared with known standards—it might be one standard or another—and that was all that the unskilled operator was doing in the circumstances.

A question was raised concerning the non-linear scale. Naturally it was possible to produce a linear scale—or at least a so-called linear scale—but it made little difference. Non-linearity was not a big point so far as disadvantages were concerned. In point of fact, the type of non-linear scale produced in the feed gauge was a deliberate exaggeration of an inherent characteristic of the particular system described. It was produced because it was known that in the particular case it was an advantage.

An appeal was made in the Paper to all metrologists—electronic, pneumatic or mechanical—to try and direct themselves towards that same idea. The authors did not consider that the system was limited to air operation. In fact, they were sure that it was not.

What they were doing was to use the data which was available on that type of instrument to show what they were driving at, in the hope that other systems would adopt the same basic idea and that more and more accumulated energy and thought would be put into producing that type of gauge, rather than pure inspection gauges.

The question of governmental inspection of parts made outside was not dealt with, beyond mentioning the fact. There was much work to be done before anyone could say what advantages could be gained with that type of inspection and by using machine control in the factory supplying the parts. He knew that the I.A. and I.E.M.E. had been doing a great deal of work on that particular problem, and it might be that shortly they would have some information to give on exactly what could be done.

With regard to the point, concerning the division in two, of the problem of machine control and quality control, it would have been noticed that in the 1952 Sir Alfred Herbert Paper, given by Mr. F. H. Rolt, O.B.E., some forecasts were made of future trends of gauge development, two of these being the use of gauges on machines for manipulation of the latter, and the increased use of automatic gauging machines, resulting in economy of labour and the use of ordinary gauges. They were both valid methods, and the authors did not intend to suggest in any way that automatic gauging was not valid in many cases, and in particular in cases where large quantities of parts were being produced off automatics or presses and where tolerances, compared with those on machine control, were comparatively wide.

Vote of Thanks

Mr. W. J. Morgan, M.B.E. (General Manager, *Machine Tool Trades Association*), in proposing a vote of thanks, said that being so interested as he was in the machine tool industry, he could not help but be gratified by the revelation, made that evening, that the modern machine tool was so accurate a piece of mechanism, that only the highly accurate and up-to-date measuring methods employed in the process of making the article on the machine could distinguish the inherent error of the machine, and bring it within the tolerance which was allowed on the article.

He was old enough to remember that machine dispersion was a problem in the old days when his foreman would give him a job and say: "I want you to make this 12 in. long and $1\frac{1}{8}$ in., $\frac{1}{16}$ in. and $\frac{1}{32}$ in. bore," and his most accurate instrument was a rule, and outside and inside calipers which he manufactured himself! He knew that on the particular lathe if the piece were over a certain length

it was necessary to take a trial cut first, and that it was also necessary gently to tap the machine with a lead hammer in order to take out machine dispersion !

The Lord Chief Justice said recently that he felt steps ought to be taken in the reduction of crime, to put more men back on the beat and to apply less of the police force to the apprehension of criminals. It would appear that a similar problem was presented in the Paper. There were those who were in favour of putting men on the beat to prevent the crime of producing scrap, rather than having men on the job of detecting scrap and rejecting it after it had been produced. Whichever might be right, no one would advocate taking all the speed cops out of their cars and all the plain clothes detectives and putting them on the beat, nor would those who were supporters of the other idea favour taking all the men off the beat and putting them in plain clothes.

It would seem that Production Engineers had been given a fine opportunity to sort out their minds and in the production of the components and articles for which they were responsible, to make sure that the crime of scrap was reduced to the minimum, that costs of production were kept down to a minimum, and that the quality of production was at the maximum, because it must be appreciated that the honeymoon was over so far as the selling of products was concerned. He had just returned from Canada—it was not by any means his first visit—and he had come back with the high hopes which he had when he first visited that country, although he felt rather solemn with regard to the task ahead. Old competitors were coming back with advantages which industry in this country did not enjoy. They had enjoyed a breathing space; they had been able to reflect and to improve their methods without being constrained, at the same, time to keep old markets and open new ones. They were new to the game once more. It was necessary to see that they did not get too great an advantage.

Therefore, his task in thanking the speakers was a very pleasing one because he was thanking them for a task well done, and for having presented something worth while thinking about as a contribution to the end for which all those concerned were striving.

The vote of thanks was carried with acclamation, and the Meeting then terminated.

Communications

In order to clarify certain points raised during the Discussion, **Mr. Richards** has now prepared the following notes:—

Non-linearity. It is perhaps of importance to go into the advantages and disadvantages of a non-linear scale a little more closely.

The point has been made that it would be better to consider the disadvantages of a non-linear scale than to benefit from its advantages, without however specifying disadvantages or refuting the benefits claimed. With respect, this contention can only be upheld when extreme accuracy is required over the whole length and at any point of a measuring scale. It is true that the curve (of size of part plotted against linear distance on the indicating scale) which is characteristic of non-linearity as opposed to the straight line of a linear calibration, is not so extremely accurate as the latter, because of the need for interpolation of points on the former.

However, the normal calibrational method for non-linear scales is, of course, reversion to a logarithmic graph for interpolations.

But the final explanation of why non-linearity here is no disadvantage *per se* is because the type of scale discussed in the Paper is not a scale indicating exact sizes over a range. It is an " approach " scale, and only one point on it needs to be more accurate than .00002 in., viz., the zero, or nominal point. When such gauges are to be used for extreme accuracy at any point on the scale, care is taken to choose characteristics which will produce a linear scale, and well-known examples are slip measuring comparators using $\times 25{,}000$ or $\times 40{,}000$ magnification, and very short base extensometers which use $\times 200{,}000$ magnification.

There is absolutely no ground in our view for considering that the deliberately exaggerated non-linearity of the feed gauge scale is in any way a drawback. Both theory and practice prove that it is an enormous advantage, with no disadvantages at all.

Automatic Inspection. We are aware that the great majority of automatic inspection machines are not used in this country as " production gauges " as we define them. However, it is being more widely realised that even on wide tolerance work (limits of over .002 in. or so) it is still a great advantage to be able to correct the machine setting accurately when the control chart, or an automatic gauge, indicates the dispersion band is approaching the limit or limits of tolerance.[1] No " handle on the machine " is needed for gauges to be able to help on this.

A wide experience of closer tolerance work has proved to us that Machine Control can, and usually does, reduce the percentage of faulty machining below the percentage of faulty automatic inspection, and some cases are known, as it was suggested during the Discussion might be possible, of an expensive automatic gauge actually becoming disused in favour of individual sampling and use of a setting adjustment gauge.

On the case quoted of a small brass fuse cap, we will suppose that the tolerances were, in fact, close enough to make this a difficult job. That is, that there is real difficulty in holding the

tolerances, rather than a mere likelihood of an occasional part going outside due to a faulty or over-late adjustment of the machine setting, or else from a spasmodic fault in the set-up.

Machine Control, of course, has never specified measurement of the part in such a case on the machine, smothered in oil. Either setting check gauges, or a multi-dimensional (not to be confused with an *automatic* multi-dimensional) setting check gauge would be used on sample parts to check dimensions—for the purpose of correcting the various elements of the machine setting if necessary.

Mr. Loxham outlined this method, using a small brass fuse cap and an injector part as illustrations, at the G.A.M.I. Meeting on " Modern Methods of Checking Dimensional Interchangeability " in Paris last December, and he was then, in our view, absolutely correct in his solution and exactly along the lines of Machine Control.

The " gauge control of machine tools " must not be supposed to be limited to mere gauging of main slide movements, for the latter is only one way of translating size indications into accurate adjustment or manipulation of the machine.

However, it was probably the case on this component, that tolerances were actually comparatively wide; should, however, an important possibility of rejects be present, setting adjustment gauges can still nearly always simplify the difficulty, acting on the information given by the setting check gauge. Since automatic inspection machines are based on more accepted ideas, it is usually easier to accept their use, but unless an effort is made to use them on Machine Control lines, they are really only of advantage for inspecting finished parts bought out.

Trades Unions Reactions

Experience of Machine Control very extensively used in closed shops has shown that Trades Unions are very fair-minded on the subject. This is not at all surprising, of course, and even less so when the subject is looked at in proper perspective, for the use of a production gauge of the indicating type is in the same category as the use of a limit gauge, such as a snap gauge.

A Feed Gauge is used for the same purpose as the graduations normally supplied on the in-feed wheel. The name of the type of Feed Gauge discussed in the Paper, in various foreign languages is almost always " pneumatic vernier."

If there could be an objection to this contention, what would be the reaction to the in-feed vernier suggested by industrial psychologists,[2] which lies half-way between a Feed Gauge and a normal vernier drum?

The best way of stating the case is to point out that the use of the equipment does not give an inherent increase in the operator's

own skill. While he is using such instruments he is doing his job more skilfully, that is certain. So would he be if he were given the use of a much better quality machine tool. But remove the instruments, or shift the operator to a machine not so equipped, and the contention is unanswerably correct.

During the Discussion following the presentation of the Paper, it was said by some that the operator's skill was decreased, and by ourselves that it was increased.

Allegory again may be the best way of explaining. There is no doubt that a man in a motor-car will travel faster than a man in a horse-drawn carriage. The motor-car is the reason for its driver " being more skilful " in attaining a given goal. A man in a house in Hampstead can, by using a television set, see the tennis at Wimbledon better than a man with a telescope on the roof. Indicating gauges on machines serve as the television screen for a spectacle which would otherwise be out of sight.

In considering whether skill is increased or decreased, we must compare *like with like*. In this case, skill in attaining a given quality of production cannot be compared as between the skill of a good man with an " obsolete " method and a good or average or poor man with a much improved method.

REFERENCES

1. G. Claesson, SKF, Sweden, " Some Examples of the Application of Statistical Quality Control in the Manufacture of Ball Bearings." Proc. G.A.M.I. Meeting on Modern Methods of Checking Dimensional Interchangeability. Paris, 17.12.51. (Microtecnic—Lausanne, Vol. VI, No. 2. March/April, 1952.)
2. "A New Indicator of Machine Tool Travel." C. B. Gibbs, APU 177/52. Applied Psychology Research Unit, Cambridge, July, 1952.

The following communication has been received from **Mr. E. Jones** (Chief Inspector, *Muirhead & Co., Ltd.*):—

" I was privileged to attend, as a visitor, the lecture on Machine Control, and I must admit how disappointing it was to find that apparently, in most works, Production and Inspection are still at loggerheads. This seems extraordinary to me. I thought that surely, in these enlightened days, Inspection had become an asset to Production—not a hindrance.

" As I see it, until the relationship between Production and Inspection improves, Machine Control, Quality Control, or any other means of Inspection, cannot work efficiently and economically.

" To consider Inspection still a necessary evil is our inheritance of early days when anyone who was redundant in the Works was pushed into Inspection. No matter how efficient a man might be on a jig borer or a lathe, that alone will never make him a good Inspector. He has a different line of approach. Present-day

inspection is a 'craft' or 'art' on its own; correct training and practice in metrology and the kinematics of instruments are required. With this basic knowledge and the experience he gains he is in a position to use his head as well as his hands; he becomes a liaison between design, production buying and sales. With his specialised training he is able to assist and recommend on problems which affect production.

"Remarks made by various speakers at the Meeting gave the impression that a percentage of rejects was satisfactory, but as the Ministry of Supply spokesman so rightly stated: 'When lives of men are at stake, only 100 per cent. inspection is good enough,' and the 100 per cent. must be right.

"If units outside the limits are passed on final inspection, it can be assumed that they will be quite satisfactory. This being the case, the tolerances should be relaxed to the standard of the worst acceptable item. Opening tolerances improves production.

"Machine Control has many desirable features, but it depends on the integrity of the machine operator, assuming (as the authors of the Paper do) that further inspection can be dispensed with. Much as we dislike having to admit the fact, we cannot be fully trustful of the operator, or else Production would not fear Inspection and Ministry Inspectorates could be dispensed with. In fact, it is only the bad or careless worker who dislikes having his work inspected. The good operator has nothing to fear; he has done a good job and, call it pride if you will, he likes to have his work examined.

"Again, Machine Control, as the authors state, can only be applied (economically at any rate) to certain work or certain machines where fine limits are called for. They state that only on the machine can accurate sizing be carried out and that, eventually, by relatively unskilled personnel. This is not quite so. All machines vary with temperature—room temperature—but more especially machine operating temperature. Even a varying flow or direction of cooling fluid on the cutting face can give errors, especially on some light alloys. Very small errors, maybe, but then we are working to very small tolerances. Second operations cause stress relief on earlier work with a resulting dimensional change. Hence, even with the two gauges per machine advocated, a considerable amount of skill is required to allow for the above and many other disturbances.

"To consider limit gauges still a question of feel is like the old-timer who never uses a ratchet on a micrometer; both are incorrect approaches. Limit gauges of correct design and correct weight need not be feared by personnel using them, and feel is eliminated. Similarly, if the old-timer reads the B.S. on micrometers giving the

tolerances allowed this instrument, never again would he guarantee to *measure* to .0001 in. (*Compare* with correctly set ratchet—yes.)

" The automatic inspection method referred to by a later speaker is ideal for mass production where percentage cost of rejects is low, and where fine tolerances are not required. Except for setting up and checking of this equipment, Inspection can be avoided. True, these automatic testers are expensive, but they can usually deal with the output from many machines, thus economising on the Machine Control method.

" Quality Control under certain circumstances can outdo both methods, but that is the point—under certain conditions. In other words, each and every problem should be tackled separately, and tackled by an efficient Inspection Department, which must primarily have the means to measure accurately or check any manufactured item or incoming material. Secondly, it must have the personnel with authority and ability to make decisions on how each item will be dealt with.

" The sooner Management realise that Inspection is a ' craft ' on its own, requiring training and experience of *Inspection* method and approach, not years of *Shop* experience where the approach is of a necessity different, the sooner will harmony exist between the various departments, and production will improve."

Mr. Richards, in reply, agrees with Mr. Jones' statement that Machine Control and other systems in the same spirit cannot work efficiently until the relationship between Production and Inspection improves. He continues :

" How can this relationship be improved ? It will not change of itself, hampered as it is by existing conditions. If, however, Production Gauges and setting adjustment gauges are given to the machine operators, the ensuing possibilities and repercussions will progressively steer the factory organisation to a better degree of integration—because the means to permit a change will be there.

" An example of one of the many ultimate possibilities is, as we said, sometimes the suppression of 100 per cent. final inspection. For, as Mr. Jones implies, 100 per cent. inspection is not the same thing as 100 per cent. correct acceptance or rejection.

" It is not perhaps widely enough realised just how difficult a job we often ask our machine operators to do. Some artists can surmount the difficulties, but the average individual cannot. For there is no such thing, where skill in manipulation is concerned, as ' bad ' labour. Labour is what it is, and it is up to us to help it with as many facilities as will aid our production economy at the same time. The artist has every right to be proud of having his work inspected and found good—he has done it blindfold and it is an achievemen.t But why not remove the blindfold ?

"To widen tolerances improves production rates, it is true. But it does not, unless we not only grade but also pay far closer attention to errors of form, improve quality. Quality can only improve by reducing the 'scatter' between the dimensions of successive parts, and between fits on random assemblies.

"Next, we are not alone in feeling that the use of limit gauges does not help production, and that their use should as far as possible be confined to checking for acceptance only.

"Lastly, we most heartily agree with Mr. Jones on the value of aid to Production by the Inspection. But whether these functions should truly be exactly as he visualises them, we are not so sure. Some improved device is still needed between the Inspection and the machine to translate the information given by the Inspection, the Control chart or the Production Gauge, into correction of succeeding components.

"Mr. Jones may be reassured on the reality of the benefits found with Machine Control, for these have been found empirically as well as theoretically. We cannot, however, judge a method by standards, applying to other methods, which do not give sufficient security to allow the same possibilities."

BUILDING A LOCOMOTIVE

by COLONEL G. RIGBY, O.B.E., G.M., A.M.I.Mech.E., M.I.Loco.E.*

Presented to the London Section of the Institution, 10th January, 1952

THE British locomotive industry started with the first locomotive built by Trevithick in 1804, and has expanded considerably since that time. Between 1804 and 1829, 44 locomotives were built and at the Rainhill Trials in 1829, the successful "Rocket" entered by George Stephenson, was the 45th locomotive to have been built and might be said to be the forerunner of present-day practice, in that Stephenson introduced in that locomotive the system of creating a draught on the fire by means of the exhaust steam from the cylinders, and also a tubular boiler, both features being standard practice to-day.

The locomotive weighed, with its tender, 7½ tons and could haul on the level a load of 17 tons, including the engine, at a speed of 20 miles per hour.

Incidentally, George Stephenson superintended the construction between 1821 and 1825 of the Stockton and Darlington Railway which was the first public railway in the world. The track covered a distance of 20 miles, and 100 years later the total track in all parts of the world was 700,000 miles.

Fig. 1 shows the replica of George Stephenson's "Rocket" built by Robert Stephenson and Company of Darlington, at the behest of Mr. Henry Ford for his Detroit Museum.

Exporting Locomotives

It is interesting to recall that the first locomotives to be used in Germany, Japan and the U.S.A. were all built in this country. The first two were built by the Vulcan Foundry and the American locomotives by Stephensons. The Vulcan firm built two locomotives for the Camden and Woodbury Railroad in 1833, and three more for the South Carolina in 1835, together with one for Belgium.

Following these were five for the Paris—St. Germain Railway, whilst Russia purchased one in 1837. In the same year we supplied two locomotives to the Kaiser Ferdinand Nord Bahn in Vienna. At this time too, the home market was developing with the rapid building of lines between cities and towns, and railways such as Liverpool and Manchester, Leicester and Swannington, London and Birmingham, London and Greenwich, Bolton and Leigh, the Great Western, London and Southampton, Birmingham and Derby Junction, all figure in the order book for the years 1830-1839.

* *General Manager, Vulcan Foundry Ltd., Newton-le-Willows, Lancs.*

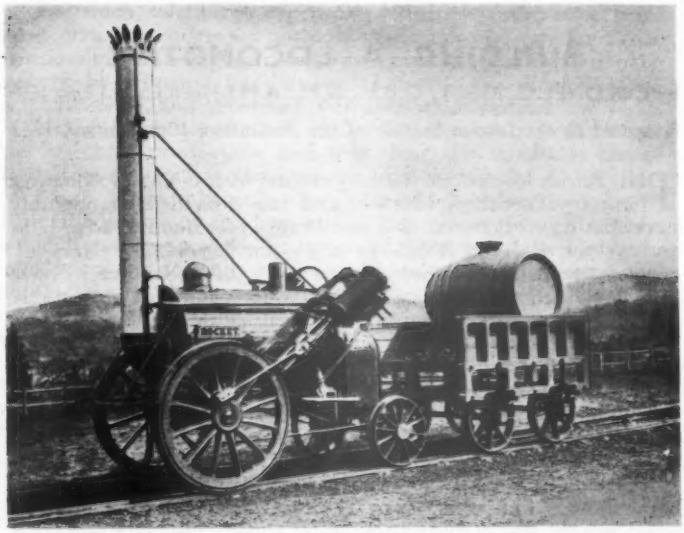


FIG. 1

Locomotives Exported to India

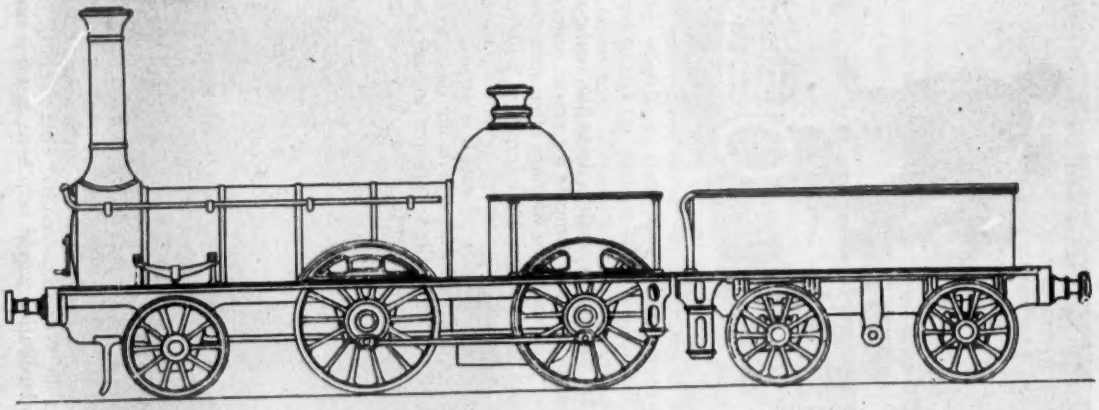
Fig. 2 shows the first locomotive supplied to India, which was in course of building at the end of 1851 and was delivered in 1852 by Vulcan Foundry Limited. Since that time we have supplied an average of one locomotive per fortnight for 100 years, this being a total to date of 2,860 locomotives for India, or the Continent of India including Pakistan.

Fig. 3 by comparison, shows the latest type of locomotive we have built for India, a large "WM" type tank engine for heavy suburban passenger work.

A production of one locomotive per fortnight may sound horrifying to a Production Engineer, but it is very satisfying for a locomotive manufacturer who has to rely largely on exports to keep his shops busy and to avoid losing his skilled labour force.

The Private Builders' Difficulties

The locomotive industry of this country originally supplied most of the locomotives for the development of the home railways, but it eventually became the fashion for C.M.Es. to design and produce their own locomotives in railway workshops; and in consequence there is now only a small percentage of



The first Locomotive for India, G.I.P.R.

FIG. 2

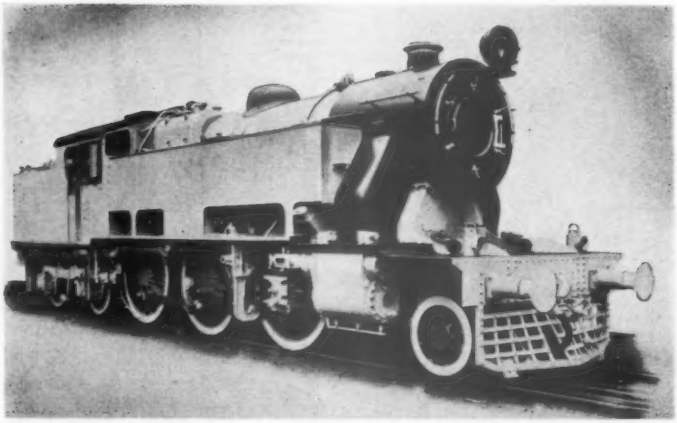


FIG. 3

spasmodic orders for the private builder from the home railways, and the private builder is left to compete for export orders against the Continental and Japanese firms who are often subsidised.

In view of the fact that the private locomotive builders of this country constitute a heavy engineering potential, which is of considerable strategic value in time of war, it is surprising that the Government who now control the railways do not insist on a regular proportion of new work being allotted to the industry and thus assist the export drive in this age of planning, in which there still seems to be plenty of scope.

Unless there has been a war which has interrupted a railway's replacement programme and thus necessitated the ordering of large numbers of locomotives, the usual run is of the nature of, say, 20 off, which is not of very great interest to a Production Engineer, but is welcome to the locomotive engineer, nevertheless.

The old L.M.S. Company claim to have built approximately 3,000 locomotives of each of two types over a series of years, but private builders never get near such numbers, and little quantity production is possible. The nearest would be the number of austerity locomotives, which were started during the war, of which type Vulcan built 390 and the other British builders, 545. But if a number of comparatively small runs follow each other and each of them necessitates design work, a state of unbalance between the Drawing Office and the Workshops results. One might be tempted to assume that standardisation would help here, but it is surprising

how the various railways insist on their individual ideas and designs. Even those Colonial Railways which are associated with the Crown Agents for the Colonies insist on adherence to their own specifications for minor details. It is hoped that the meetings which now take place periodically between the C.M.Es. of the Colonial Railways, to which the Locomotive Manufacturers' Association of Great Britain send representatives, will ultimately be of considerable assistance in achieving some degree of standardisation which, however small, would be most welcome.

One of the obstacles to standardisation is, of course, the number of firms who manufacture proprietary fittings, such as injectors, brake gear, lighting equipment, to name a few of the obvious examples. But an item like a washout plug, or a fusible plug, could easily be standardised without wounding the *amour propre* of even the most sensitive C.M.E. In a recent paper presented to the Institution of Locomotive Engineers, Mr. Cox of the Railway Executive mentioned thirty-eight items which it had been found possible to make standard on all six classes of standard engines; but, on the other hand, there were seventy items which had had to be modified to suit the various divisions of British Railways !

The Locomotive Manufacturers' Association have produced some standards for limits and fits for the industry which are widely

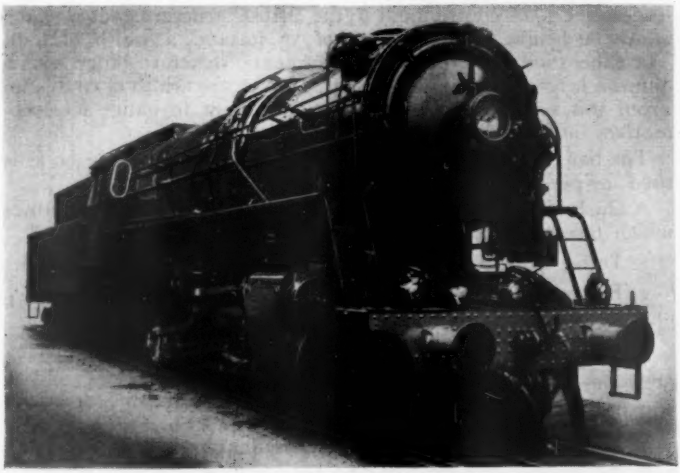


FIG. 4

used, but here again they cut across the home railways ideas, and the British Standards Institution are endeavouring to do something about it.

The Liberation Locomotive

The Liberation locomotive (Fig. 4) was designed for U.N.R.R.A. during the war. Such of the locomotive engineers of European countries as escaped to this country were consulted, and they collaborated in the design stages. As a result this locomotive has a wide application, as it was intentionally designed for use in any of the European countries requiring rehabilitation when the war had been won. In point of fact, these locomotives are now running in Poland, Czechoslovakia and Yugoslavia, with ten additional locomotives being supplied to the Grand Duchy of Luxembourg.

Notice the high pitch of the boiler which, of course, is possible with the European structure gauge, and that the frames used on these locomotives are of the plate type. As will be seen, the round top firebox is quite a wide one and had the designer been confined to a more stringent loading gauge, he would probably have had to set the pitch of the boiler lower and use a bar frame.

Two different types of fireboxes were used on the Austerity and the Liberation. They are both used with plate frames, and the difference in the pitch of the boilers is noticeable. The Austerity locomotive is, of course, built to the British structure gauge, which allows a height at the centre of 13 ft. and a width of 9 ft. The Liberation was built to the Continental structure gauge, which allows a height at the centre of 14 ft. 0½ in. and a width of 10 ft. 4 in. From this will be appreciated the limitations in gauge for locomotives built for British Railways.

The bar frame is the ideal for a firebox with wide legs such as is used for oil burning, where plenty of air is essential.

A few brief details of some of the alternative basic design features which face a locomotive designer are as follows:—

1. Duties to be performed, i.e. passenger, freight or mixed traffic.
2. Structure gauge.
3. Ruling gradient.
4. Minimum curvature to be negotiated.
5. Permitted axle loading.
6. Bridge characteristics.
7. Tractive effort and adhesion factor demanded.
8. Particulars of fuel available, i.e. oil, coal or, in some cases wood.

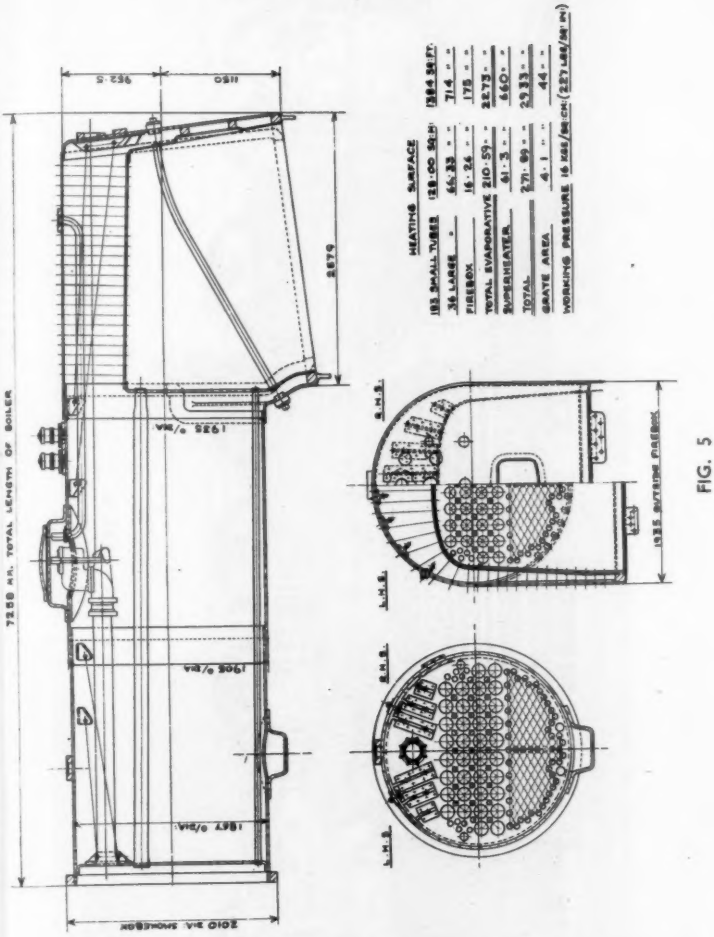


FIG. 5

The designer would then decide on a suitable wheel arrangement, whether to use plate or bar frames, the number of cylinders, and what evaporative factor and superheat figures he would require to give the specified performance.

Locomotive builders are usually given types to build and therefore rarely have a free hand. When a specification demands something

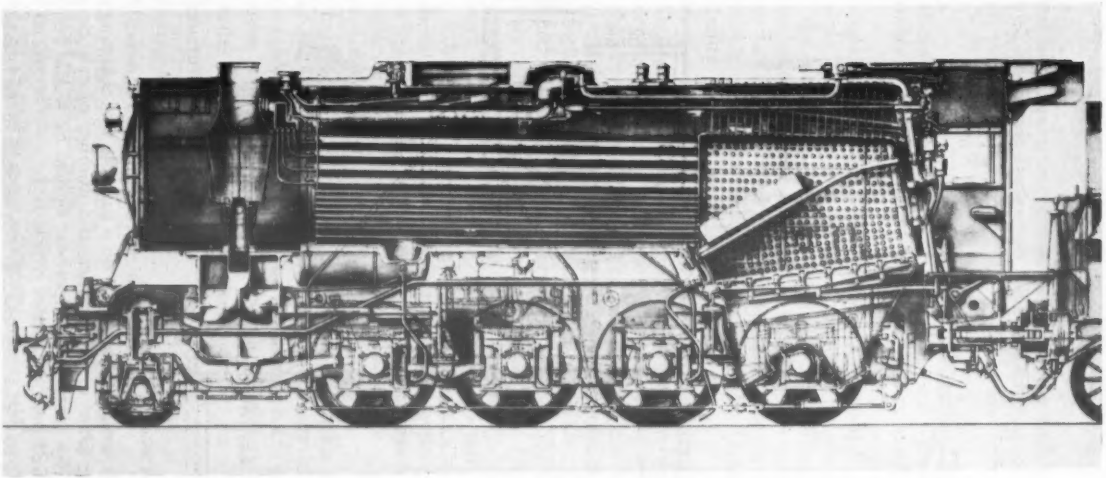


FIG. 6

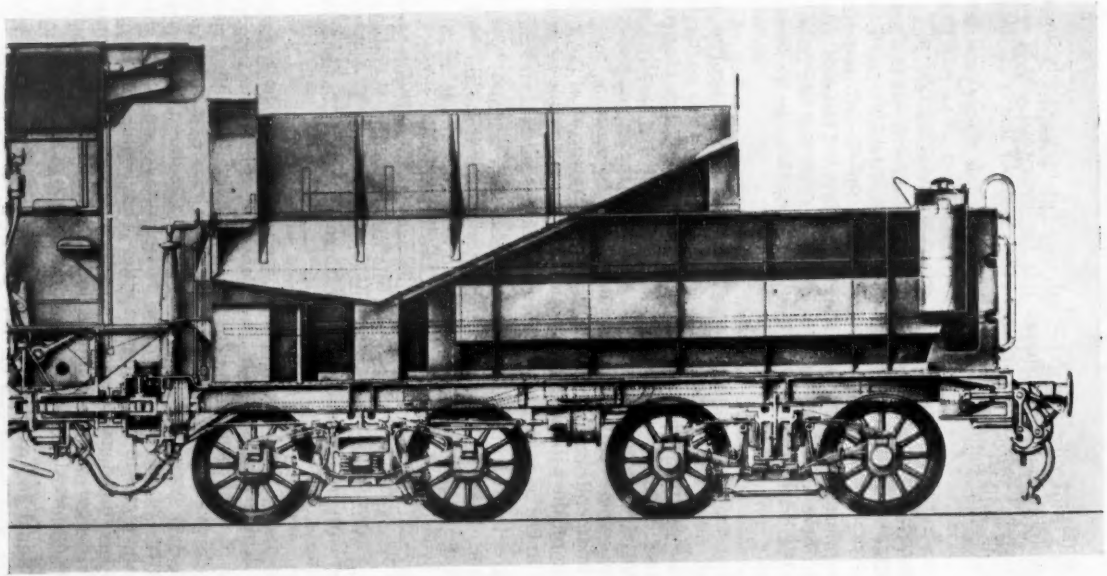


FIG. 7

which they think might be improved, they can only politely suggest a modification, but the customer has the last word and is *nearly* always right. Cases do occur where the customer leaves all design work to the builder, but this is infrequent.

Cross Section of a Boiler

A cross section of a Liberation boiler (Fig. 5) shows the comparatively narrow water space round the firebox. The inner firebox is positioned in the outer firebox by the foundation ring, and is supported by side, radial and roof stays. The arch tubes, of which there are three, serve two purposes; on the one hand to support the brick arch, and on the other, what is more important, to promote convection.

Between the firebox tubeplate and the smokebox tubeplate are 183 small tubes and 36 large superheater tubes in this particular boiler. Inside the superheater tubes are the superheater elements. In the case of oil fuel being used, the elements are usually some 18 in. shorter than normal to avoid burning of the return bends by the flame, whose path through the firebox is made as long as possible in an endeavour to ensure that the temperature of the gases impinging on the tubeplate is minimised as far as possible to about 1300° F.

A comparison of the life of a steel firebox as compared with a copper one shows that ten steel fireboxes of the Merchant Navy class averaged a mileage of 216,000 each before requiring complete renewal, whereas ten Princess Royal Class Locomotives fitted with copper fireboxes averaged 758,000 miles each. The criterion is the question of water, which can be a nightmare to the locomotive engineer. With untreated water, steel fireboxes give a poor life compared with copper, and water treatment is a costly business for some railways.

The staying of the inner and outer fireboxes is done by screwed stays in British practice. On the Continent during the war, a technique of using plain stay bar in a plain hole and welding each end was developed. This practice has been carried on since the war, and it is now standardised on some Continental railways. In the areas of increased stresses, flexible stays are used, thus allowing the plates to " breathe " a little. The flexible stay head is round and sits inside a spherical cup which is welded to the outer plate. A copper washer is fitted under the stay, and after the staying is completed, a cap is screwed into the cup head.

Longitudinal and palm stays are fitted to support the barrel and back plates, and barrel and smokebox tubeplate.

The Locomotive in Cross Section

The main frames have to withstand most of the stresses and the modern trend is towards bar frames. These are usually gas-cut out of slabs, and for a 2-10-2 locomotive shortly to be built the rough slabs required from the rolling mills are 12 tons each and 44 ft. 6 in. long.

The boiler sits on expansion brackets under the firebox (Fig. 6) and is supported by its smokebox on a saddle at the front end. The smokebox saddle is sometimes integrally cast with the cylinders, either in two halves or as one piece, or else is cast separately as a frame stretcher casting between outside cylinders.

The valve motion and slide bars are supported by brackets bolted on the frames, and the cylinders are bolted direct to the frames.

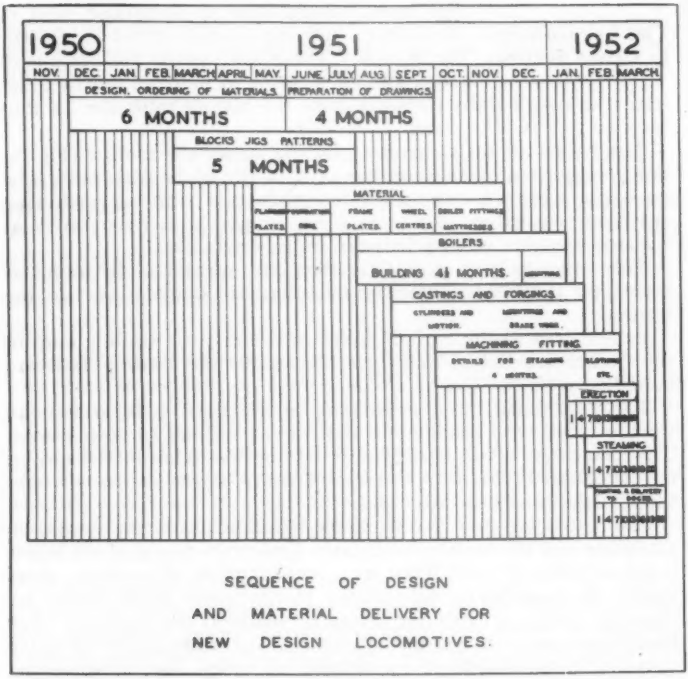
In addition to the various frame stretchers, the trailing ends of the frames are bolted to a dragbox, whilst the leading ends are bolted to a buffer beam.

The axle boxes are free to slide in the horn gaps, which are usually faced with manganese steel liners, welded to horn blocks. The locomotive is supported by spring links on to laminated springs on the coupled wheels and where necessary, bogies or pony trucks support the hind and front ends.

Palm stays are provided from the barrel plates to the smokebox tubeplate and the firebox backplate. Under the barrel of the boiler is a mud collector, and there are a large number of wash-out plugs which are essential for easy access to the inside of the boiler for cleaning purposes. In the dome is provided the regulator and from the dome, where saturated steam out of contact with the water is available, most of the steam supplies are taken. Behind the dome are two Rosspop safety valves. The pipe to the flange on top of the firebox takes steam to a steam stand, from which various auxiliary services take their steam supply.

The Locomotive Tender

The tender (Fig. 7) has to be designed to carry sufficient fuel and water with a margin of safety between the watering and fuel points when the locomotive is working to capacity. Where coal is used, the bunker is designed to " trim " the coal down to a shovelling plate, or, if a mechanical stoker is fitted, to the propelling screw trough, which feeds the coal to the nozzles at the firehole door. The modern trend is towards the all-welded tender, though some C.M.Es. still prefer rivets. In the water space of the tender, staggered surge splate are fitted and these are bolted to avoid excessive rigidity. Spring-loaded side buffers impinging on rubbing blocks are provided on either side of the drawbar between engine and tender, to control " hunting " of the tender.



SEQUENCE OF DESIGN AND MATERIAL DELIVERY FOR NEW DESIGN LOCOMOTIVES.

FIG. 8

Design and Material Delivery Requirements

An average of six months is allowed for the design staff and Drawing Office to prepare drawings before actual preparation for building can commence (Fig. 8).

The basic materials can be ordered fairly quickly after the design has been started, but the manufacture of patterns and flanging blocks must wait until the D.O. work is more advanced.

Raw Materials and Equipment

In order to assess raw material consumption, an analysis by weight of a Liberation locomotive was computed. This locomotive, complete with tender, weighed 2,200 cwt. empty and required just over 2,567 cwt. of raw materials. A summary of the analysis is given on the opposite page.

	cwt.	qr.	lb.	Per cent.
Steel	2,129	0	10	82.87
Cast Iron	250	2	0	9.75
Malleable Iron	1	1	0	0.04
Copper	76	2	16	2.96
Gun Metal...	55	2	15	2.24
Lead	16	0	0	0.62
White Metal	4	1	0	0.16
Asbestos	5	2	14	0.19
Timber	11	0	0	0.43
Firebricks	8	3	0	0.32
Glass	0	1	14	0
Paint	2	0	0	0.08
Rubber	0	2	0	0
Leather	0	0	2	0
Various	6	0	0	0.24
Total ...	2,567	2	15	100.00

Steel requirements accounted for nearly 83 per cent. of the total. This consisted of mild, cast and forged steel. Sheets and bolts constituted nearly 12 per cent. of total steel requirements; general castings 10 per cent., steel bars and boiler plates 9 per cent. each, and blooms 8 per cent. Cast iron requirements amounted to nearly 10 per cent. of the total raw materials required for a Liberation locomotive; there was also a small quantity of malleable iron.

The planning and progressing of a particular order must, of course, start with the erecting shop as the datum line. Working back from the date the frames are to be set up on the erecting shop floor, a sequence of dates for machining, casting, pattern making, etc., can be determined. Jigs must be designed and finished to meet this programme and, if the boiler is a new design, flanging blocks made to enable boiler building to proceed in time for the initial steaming date. In addition there are hundreds of orders to be prepared for materials and specialities, with correct delivery forecasts made for proprietary fittings, all of which must fit into the planned programme of work for the various shops. With the material position as it is to-day, this is no mean feat, and short deliveries are constantly causing uneconomical batches to be machined, thus delaying the progressing of parts from shop to shop.

This is aggravated on machines which require considerable setting up time, and particularly applies on the flanging presses. It will be readily appreciated that short deliveries of boiler plate, for example, can completely throw out of balance a locomotive works, in which from two to three thousand operatives are working to a schedule involving only a few boilers per week.

With regard to the design of the locomotive, Colonial and overseas railways frequently make arrangements for Consulting Engineers to handle their specifications and also do the inspection of the locomotives whilst being built. The Crown Agents have their own staff of Inspectors who are used to the particular requirements of the various Colonial railways. This, of course, saves considerable time as fairly quick decisions can be obtained from Consultants in London when, for example, certain materials specified are unobtainable and alternatives have to be considered. After the drawings are approved, material lists are drawn up for the order office with instructions regarding specialities to be bought out, and deliveries required, and copies of the drawings are sent to the Planning Office for marking out with operation details, and so on.

In buying out specialities a difficulty sometimes arises over dollars, as enthusiastic American sales organisations sometimes persuade Colonial railways that their items are indepensable; in which case, the Ministry of Supply take a hand, and limit purchases overseas if the particular items can be obtained in this country.

Building the Boiler

The wrapper plate or outside firebox top plate wraps over from each side of the foundation ring. It is marked off and drilled on the flat before being bent to shape on the vertical press.

The crown plate is similarly shaped for the inner firebox, but is drilled after assembly on the shell drilling machine. The wrapper plate thus acts as a drilling jig for the operation. The barrel plates are bent to shape on rolls. The backplate or rear outside end of the firebox, together with the firebox and smokebox tubeplates, are hot flanged in presses, as is also the throat plate. The latter forms the joint between barrel and firebox, and is also the outside front plate of the firebox. The firebox plates are sometimes welded, but so far in this country the barrels are all riveted. In the U.S.A. all-welded boilers were tried successfully before the war, and to-day the German manufacturers are trying completely welded boilers.

Welded Steel Inner Firebox

The firebox shown in Fig. 9 is for an Indian railway boiler of the XP Class. The dished holes in the throat plate are for thermic syphons, and the tubeplate is in front of a combustion chamber.

Each strip of weld is X-rayed for a foot in every eight, and the metallurgist is able to point out the variations of runs, etc., to the welding operatives. The latter are trained by this means, before being passed for the high class of work demanded for welding boilers.

Instead of thermic syphons, arch tubes are sometimes used. Both are designed to increase convection, but only arch tubes are applied

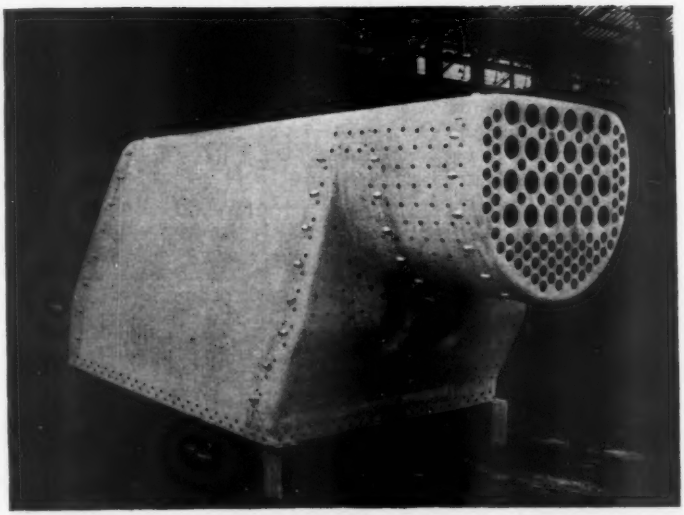


FIG. 9

to copper fireboxes due to difficulty in satisfactorily welding the steel to the copper, as would be necessary with syphons.

The inner ends of the roof stays are often fitted with nuts and washers, but when oil burning is being catered for, the stay ends are riveted over thus giving less obstruction to the flame path, and in consequence less maintenance is required, as nuts quickly burn and require frequent renewal.

Instead of the normal static fire bar grate, rocking grates are sometimes fitted for coal burning. As the name implies, the small bars can be " rocked " from the footplate, and this breaks up the clinker which " runs " on the bars, and which is so detrimental to efficient combustion. It also cleans the fire when using coal with a high ash content, and is a much easier way than the fireman using a " pricker " through the firehole door.

The small tubes are usually " belled " at the smokebox end to facilitate introduction and removal. They are expanded into the tubeplate and at the firebox, and are often beaded over to protect them from burning.

The large superheater tubes are similarly dealt with, and ferrules are used to protect the firebox ends.

The superheater elements are fitted with spherical joints to give a completely steam-tight joint.

Slotting Frames

The horn spaces and lightening holes in the frames are usually burnt out on a Hancock profiling machine from a template (Fig. 10). Pentane gas is used, and only faces required for a joint subsequently need facing on a machine. The remaining surfaces, after burning, are trimmed with a portable grinding wheel.

The facing up is done on a slotting machine with three heads, each one of which is powered by a reversing motor, which drives through an Archimedes screwed shaft. A complete setting of frames is done at one time, a batch constituting 12 single plates or three bar frames.

It may be of interest to know that this slotting machine was purchased new in 1914 at a cost of £4,139. It then had two heads. In 1919, a third head was added and the bed lengthened, at a cost of £1,135. This year, modern electrical equipment has been ordered and, at the same time, the stroke is being lengthened by 3 in. at a cost of £27,000 !

Bar frames are more frequently specified nowadays. They give excellent accessibility, and the additional strength obviates the

FIG. 10

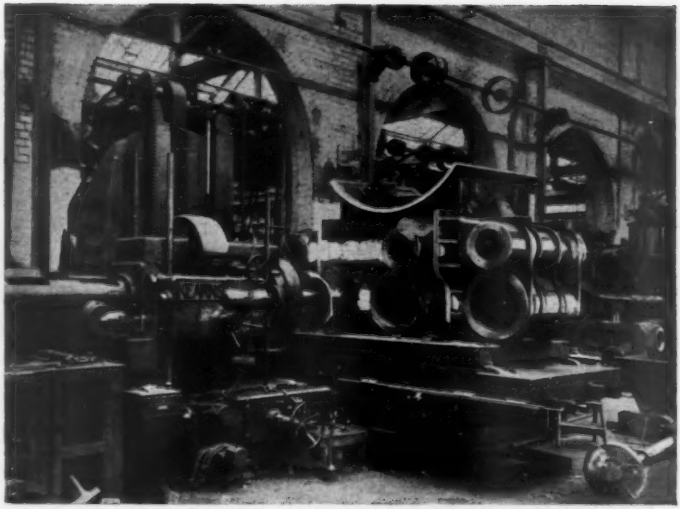


FIG. 11

weakness of the plate frame at the top corners of the horn cheeks. In the U.S.A., before steam was ousted by diesel traction, cast steel beds were in vogue. They were cast with cylinders, brake cylinders, brackets, etc., all in one piece, and machinery was available for finish machining this formidable casting. No such facilities exist in this country.

As mentioned previously, a bar frame permits a bigger boiler to be set lower, and there are many other advantages which make the present trend very understandable.

The Cylinders

Cylinders (Fig. 11) are usually made in cast iron, but sometimes in steel, and fitted with cast iron liners. The steam chest and valve ports are cast in one piece with them.

They are tested under pressure with hot water before being passed for sending into the erecting shops. When being designed the casting sometimes incorporates the whole of, or part of, the smokebox saddle. The piston, piston rods, crossheads and slide-bars are fitted with the hind cylinder cover on a jig, before being sent to the erecting shop for assembly on the locomotive.

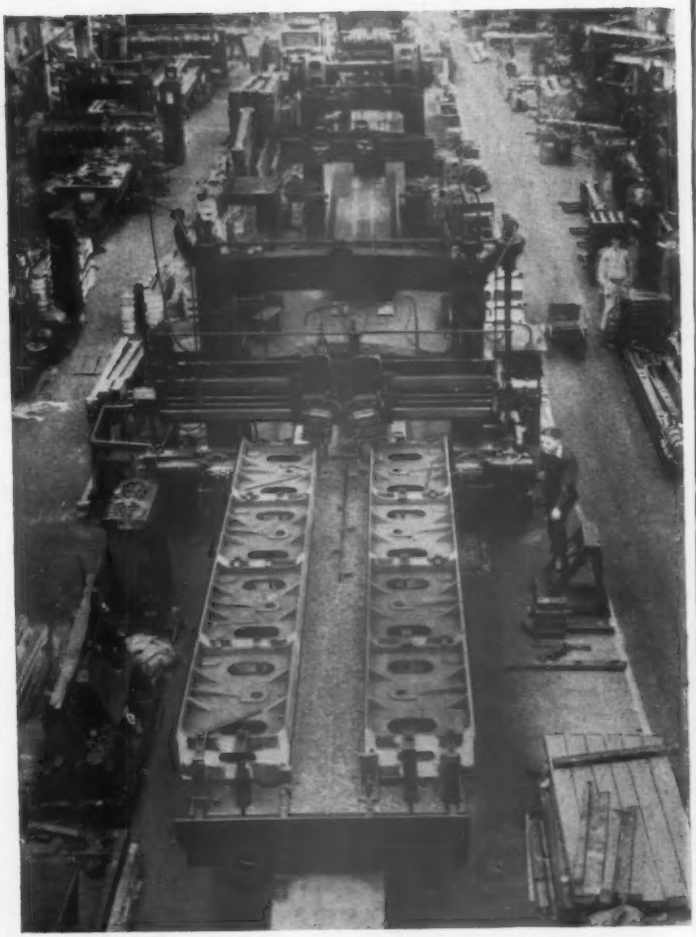


FIG. 12

The Engine Dragbox

The leading buffing gear is usually made up of plate with angles and gussets, but the hind ends of the frames are fastened to a dragbox (Fig. 12). This is sometimes a steel casting, but often a fabricated plate structure. It must house the intermediate drawbar and buffing gear, and be strong enough to take the stresses derived from that source.

General Machining and Fitting

During the manufacture of the main items, work is proceeding on numerous smaller details and assemblies throughout the works. Batches of motion details are being slotted, milled and planed. Whilst the Automatic Shop is busy making stays, bolts, studs, etc., the Copper Shop has all the pipework and clothing for the boilers in hand, and even the carpenters are busy making windows, footplate blocks or board flooring, and getting ready for the wooden liner which fits under the tender tanks on top of the frames and cross stretchers. Locomotives for hot countries usually have wooden shuttering in the cab, and the cab roof is lined with teak to break the intense heat of the sun on the cab roof plates.

Wheel centres are being machined and fitted with tyres by shrinking after heating on a gas ring. The wheels are pressed on to the axles and keys fitted. Where roller bearings are specified, these are usually fitted by service engineers from the bearing manufacturers in the wheel bay. Brake gear and pipe work is being prepared whilst the Fitting Shop is assembling reversing gear, sanding gear, axleboxes, fitting brasses into rods, to name a few of the many items which pass through their hands.

Lowering the Boiler on to Bar Frames

Before putting the boiler in the frames (Fig. 13) it has to be hydraulically tested with hot water, and again under steam, usually to one and a quarter times its working pressure, although some railways specify one and a half times the working pressure for this test.

The frames are fitted with horn blocks in the frame bay and, when set up in the Erecting Shop, have cylinders and slide bars fitted after the various frame stretchers, motion brackets, etc., are in position. They are then lined up, before the boiler is lowered on to them. You will notice in the picture that the firebox has been "lagged" and part of the clothing sheets fitted to the backplate. The lagging is either asbestos mattress or glass wool, or it may be foil mounted on wire netting.

The clothing hoops are in position ready for the finished clothing to be fitted later. All joints in the clothing sheets are covered by clothing straps. Sometimes these are specified to be stainless steel.

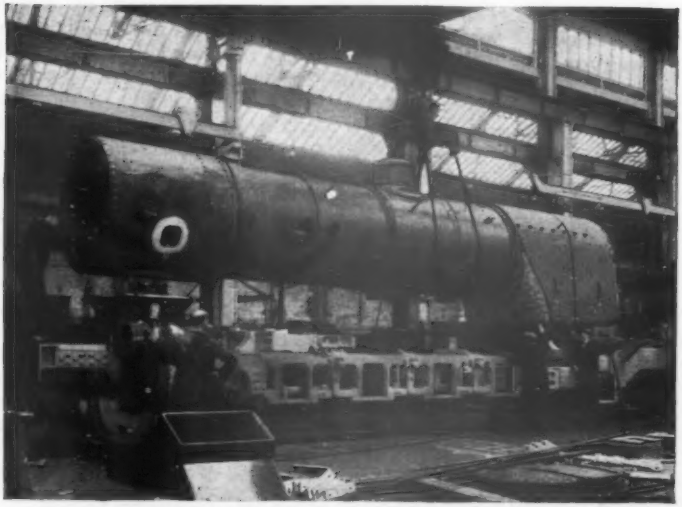
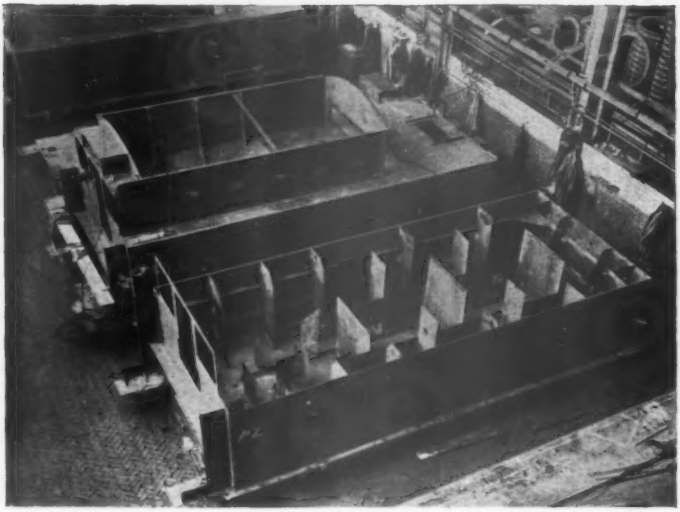


FIG. 13 (*above*).

FIG. 14 (*below*).



Once the boiler is set in the frames, the assembly proceeds until the locomotive is " wheeled " and then a final test is made on the rolls. These permit the driving wheels to revolve under the locomotive's own power, whilst the locomotive is at rest with its side rods off. Valve vents are checked, and all steam joints and all cocks and valves come under pressure. After passing this final test the engine is lifted into the paint shop for either a grey coat for shipping, or final painting as required.

Tender Construction

The tender is fairly straightforward (Fig. 14), and is usually carried on bogies. These are of the cast steel or plate frame type, sometimes with roller bearings. All welded tenders are most popular and the design varies with the requirements for fuel and water capacity, provided the limitations of the structure gauge are observed.

British Railways are providing a half cab on some of their standard engines to protect the engine crew from the weather, when tender-first working is fairly frequently required by operating conditions.

It may seem incongruous, but most locomotives for export have to be sent to the docks by road transport. The gauge is rarely 4 ft. 8½ in. and, when it is, the locomotive for export is usually outside the British Railways loading gauge.

Whilst little mention has so far been made of diesel and electric locomotives, nevertheless this form of motive power is rapidly coming to the fore, particularly overseas.

You may be interested in hearing an opinion about the future for large diesels in this country. The prime cost is much higher than that of a steam locomotive—roughly, the steam locomotive costs one-third of a diesel electric. It will thus be appreciated that the railway requires a much greater operational use to compensate for the high initial cost, and the question arises as to whether in this country there are sufficient quick turn round jobs on the long runs to justify the capital outlay. On the other hand, the medium diesel and the shunter may have a brighter future. Undoubtedly, the steam shunter spends a large percentage of its time having to have its fire cleaned, its ashpan emptied and on trips back to a coal stage or plant away from the marshalling yards. The diesel shunter can stay on continuous duty in the yards for a week between trips to a shed, and British Railways have certainly appreciated that point.

Today diesel mechanical locomotives of medium size are being tried, but they have yet to prove themselves. In America, the diesel has been sold completely to the railways and the banks and

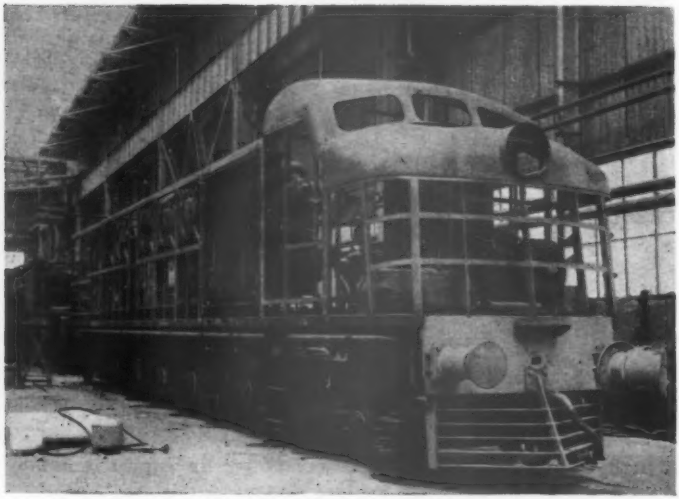


FIG. 15

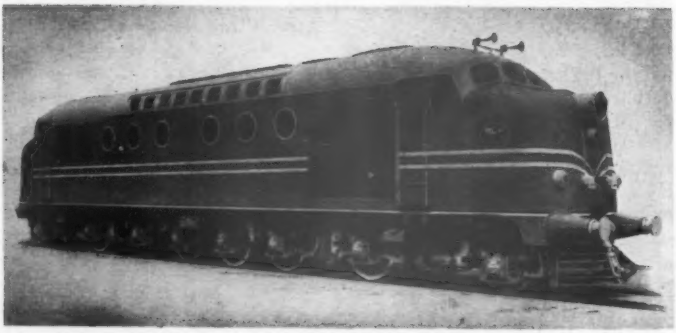


FIG. 16

finance corporations have footed the bill. In consequence the hundreds of locomotives they build each year give them a great impetus for their export trade, and it is only on the smaller gauges and new design jobs that the British manufacturers can compete.

1600 h.p. Diesel-Electric Locomotive for Egypt

As soon as the war was finished, my Company built a Diesel Erecting Shop in anticipation of a gradual trend towards other forms of motive power and, in collaboration with the English Electric Company, have built and are building diesels for Egypt, Tasmania, Queensland, Brazil and New Zealand.

We have built electric locomotives for Brazil and Spain, and are to build for South Africa and India. When I mention 63 for Spain and 60 for South Africa, you will appreciate that this market is rapidly expanding.

In addition, we collaborate with the Drewry Car Company for whom we have built numbers of small diesel shunters and power bogies, and we have on hand large orders for the 200 and 260 h.p. diesel mechanical type of locomotive for New Zealand and also for British Railways.

Some characteristics of the Egyptian State Railways 1600 h.p. Diesel (Figs. 15 and 16) are as follows:—

Gauge	4 ft. 8½ in.
Type	4—8—4
Diesel Engine E.E. Co.	163 V.T. 16 Cyl. Supercharged. 1600 b.h.p. at 750 r.p.m.
Traction Motors	6
Motored Wheels dia.	3 ft. 9 in.
Overall length	59 ft. 8 in.
Weight in working order	124 tons
Maximum axle load	17 tons
Maximum tractive effort	36,000 lb.
Maximum service speed	75 m.p.h.
Fuel Capacity	760 gallons

The same English Electric engine and transmission were also used in the British Railways 10,000 and 10,001 locomotives.

With the expansion of hydro-electric power throughout the world, the electric locomotive is naturally an economic proposition,

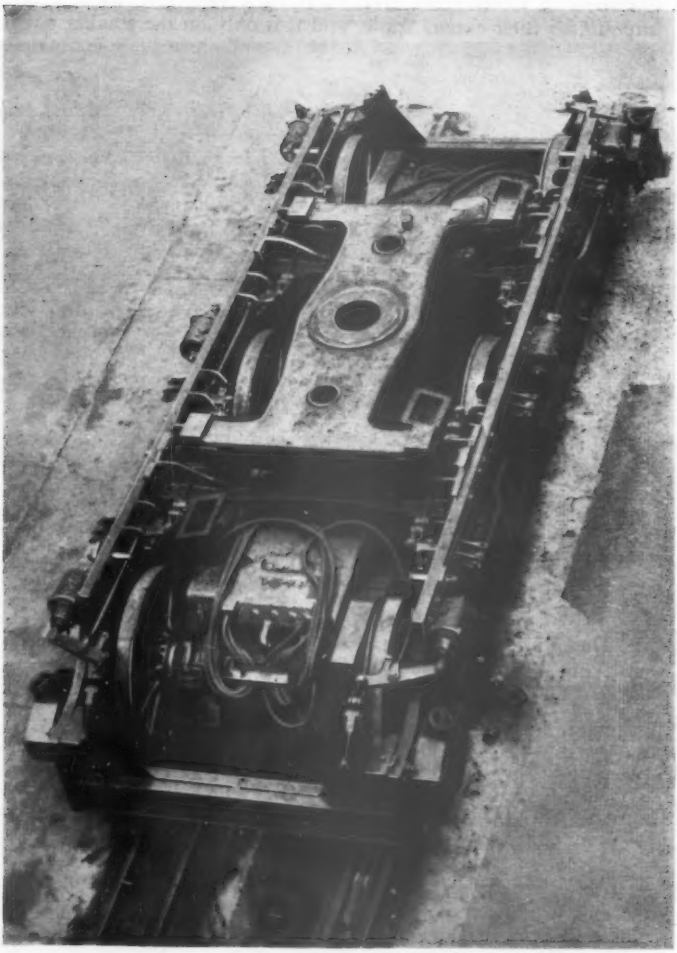


FIG. 17

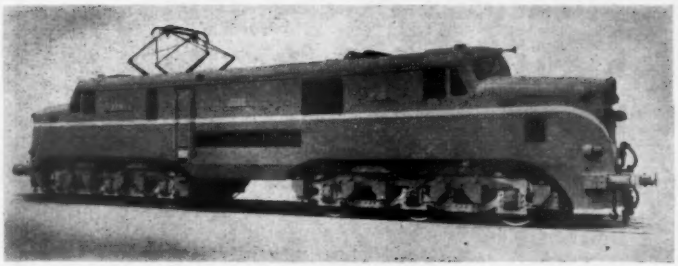


FIG. 18

and this form of traction is coming into greater prominence than ever before. The present order we are building is for Spain, and this locomotive (Fig. 17) is the most powerful of its type yet built in this country, i.e. 3,600 h.p.

Fig. 18 shows a prototype of 3,000 h.p. built for the Sao Paulo Railway of Brazil. These locomotives ran an average of 160,000 kilometres each in the first 12 months, and are giving excellent service.

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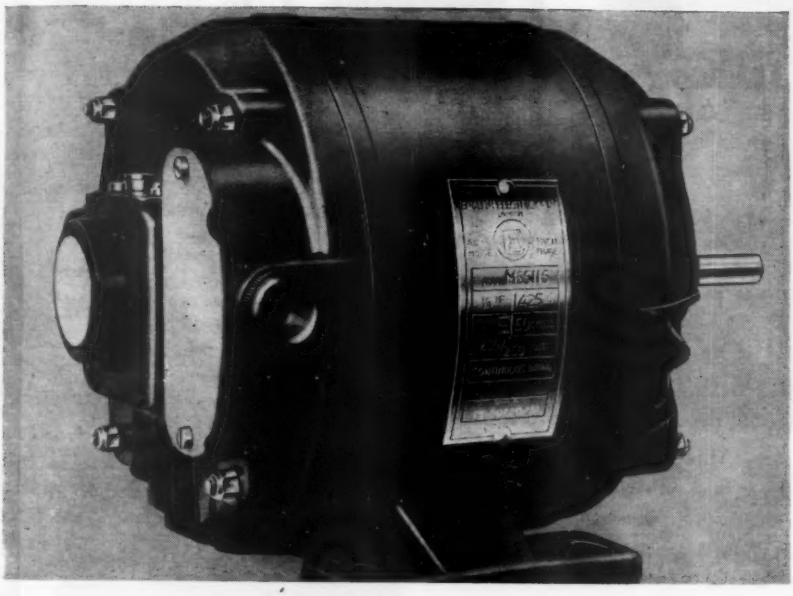

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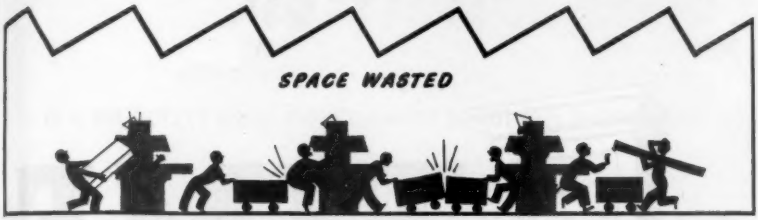

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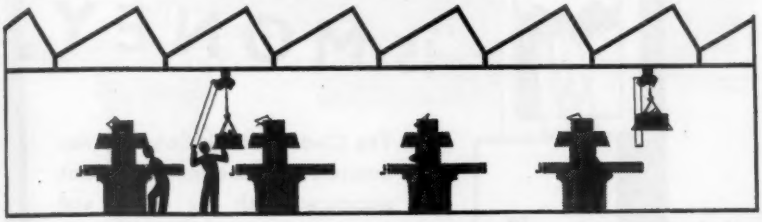

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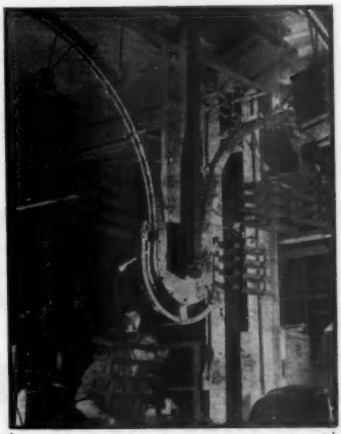

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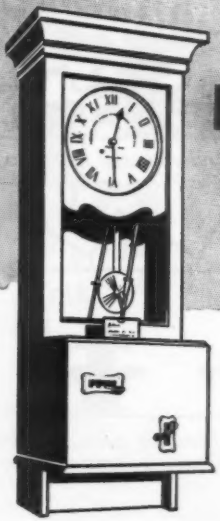

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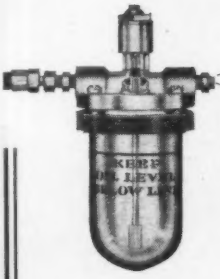

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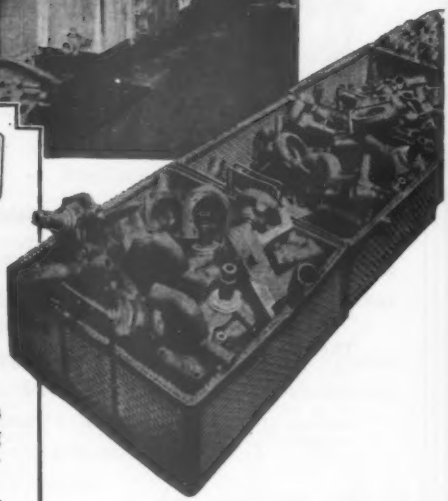

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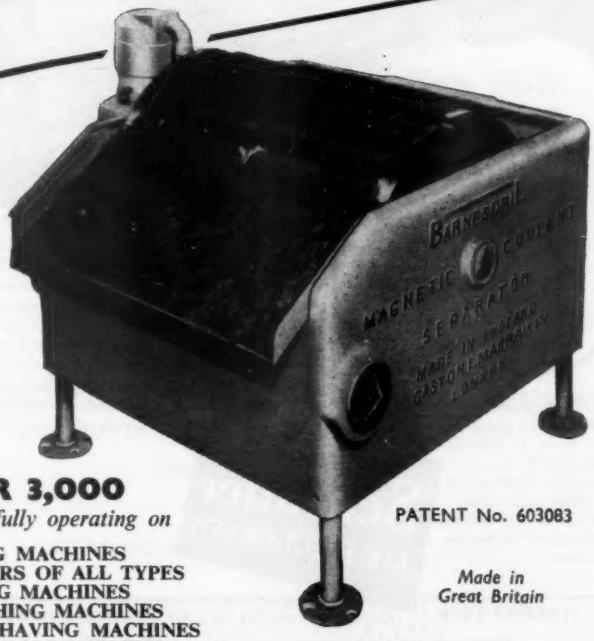

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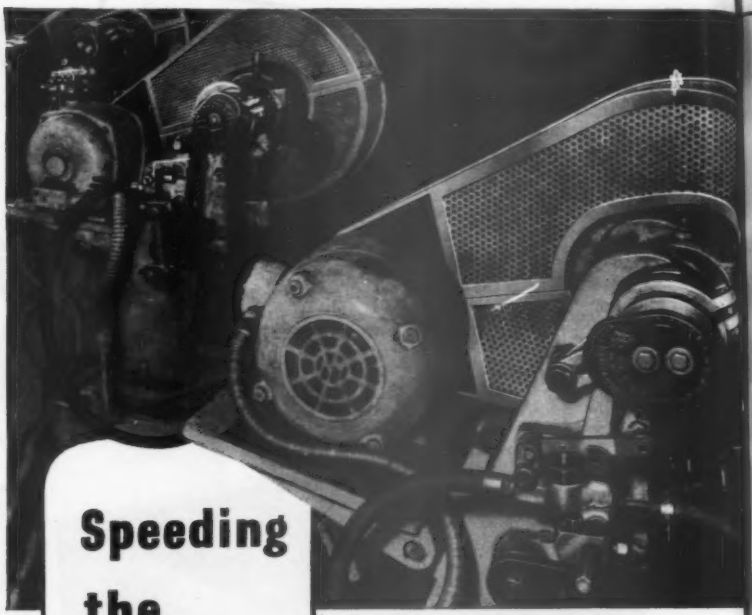

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We illustrate a battery of side flywheel presses at the works of Johnson, Matthey & Co. Ltd., Wembley. These presses are fitted with Schrader Air Ejection Sets and the cam tripping mechanism is shown.

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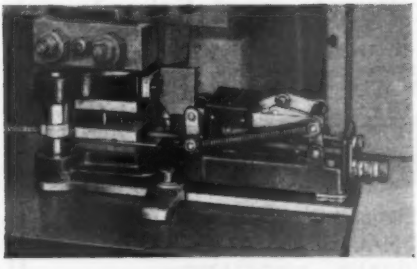

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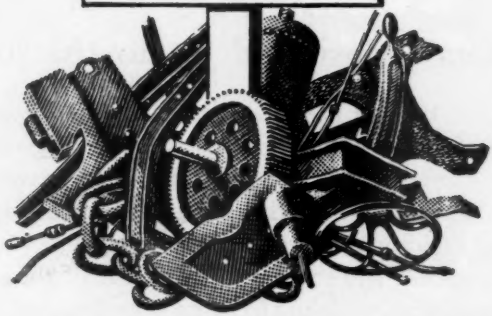
WHAT EVERY LOCAL AUTHORITY SHOULD KNOW ABOUT

scrap



What is scrap? Anything made from iron and steel which has outlived its present usefulness — such as obsolete machinery, old bicycle-frames and gardening tools, broken farming implements.

Where is it? In houses and flats, in shops and offices. You will find scrap practically everywhere if you look for it.

What good is it? No good at all in its present state. But send it back to the steelworks and it can go to make the new steel that all steel-users need. Remember—a ton of scrap may make a ton of new steel.

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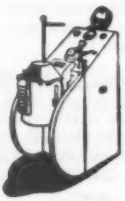

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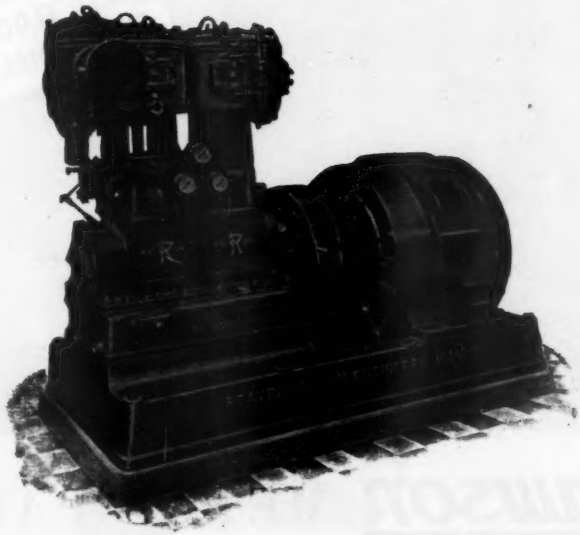

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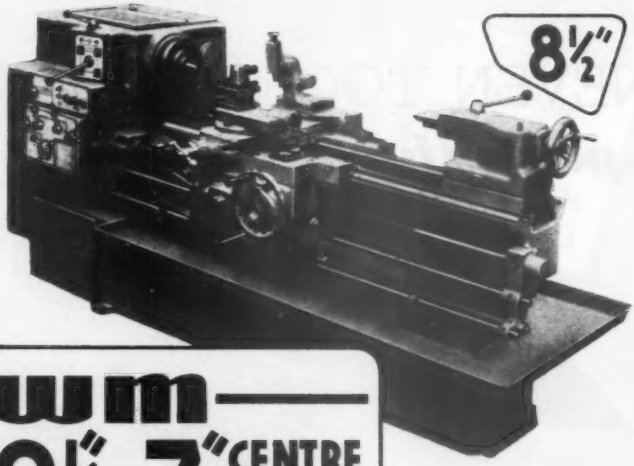

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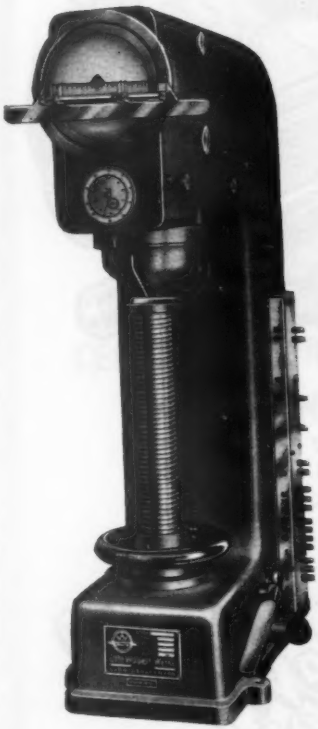

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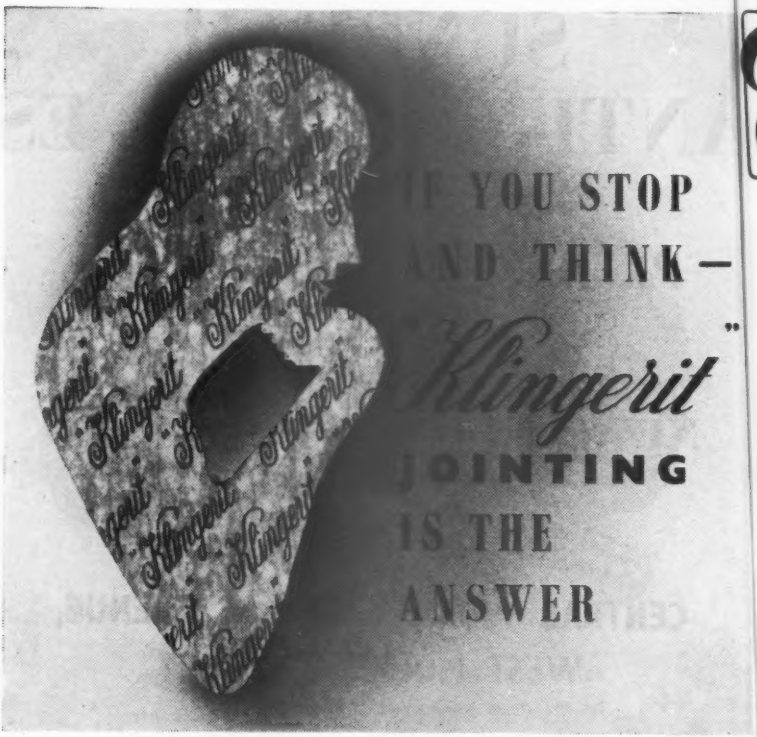

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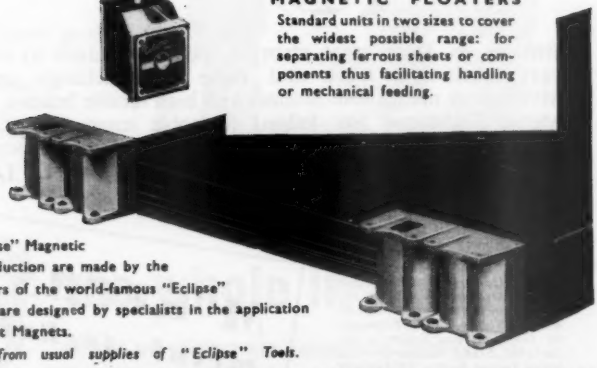

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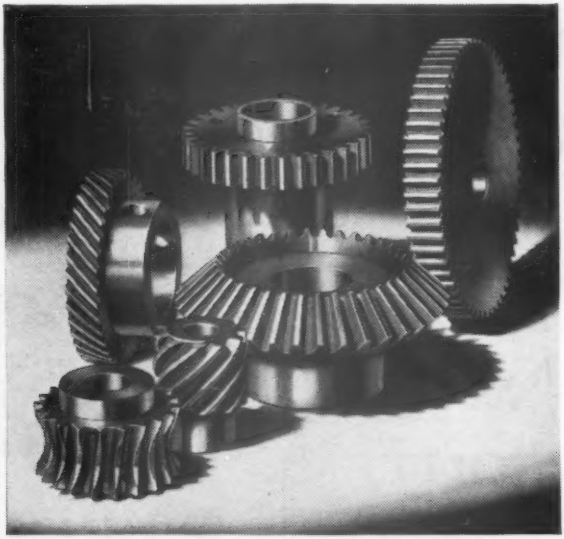

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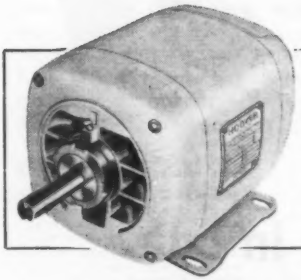

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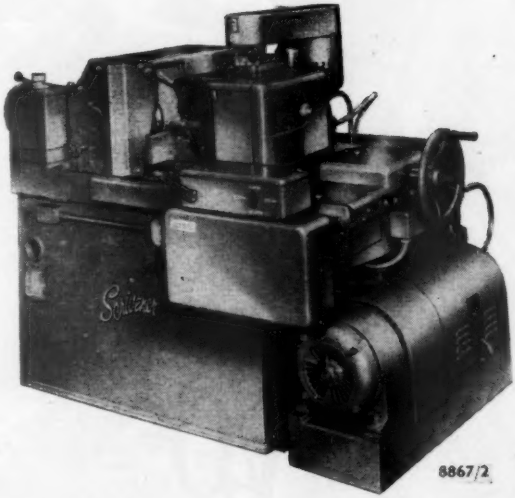

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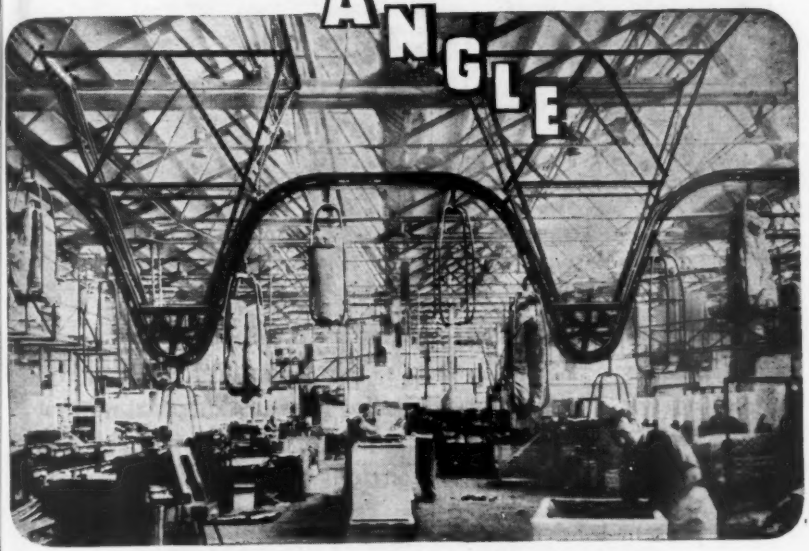

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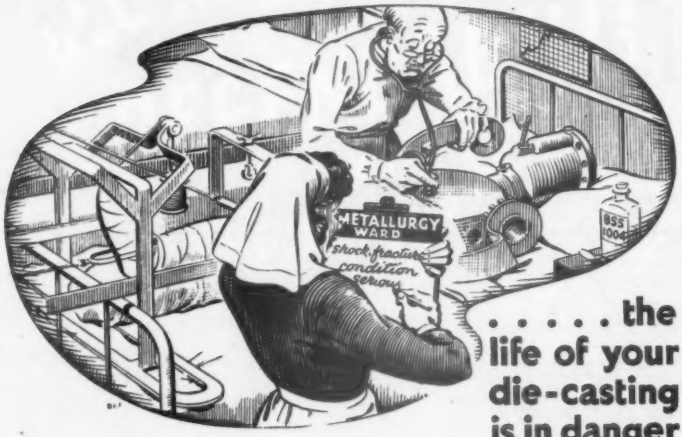

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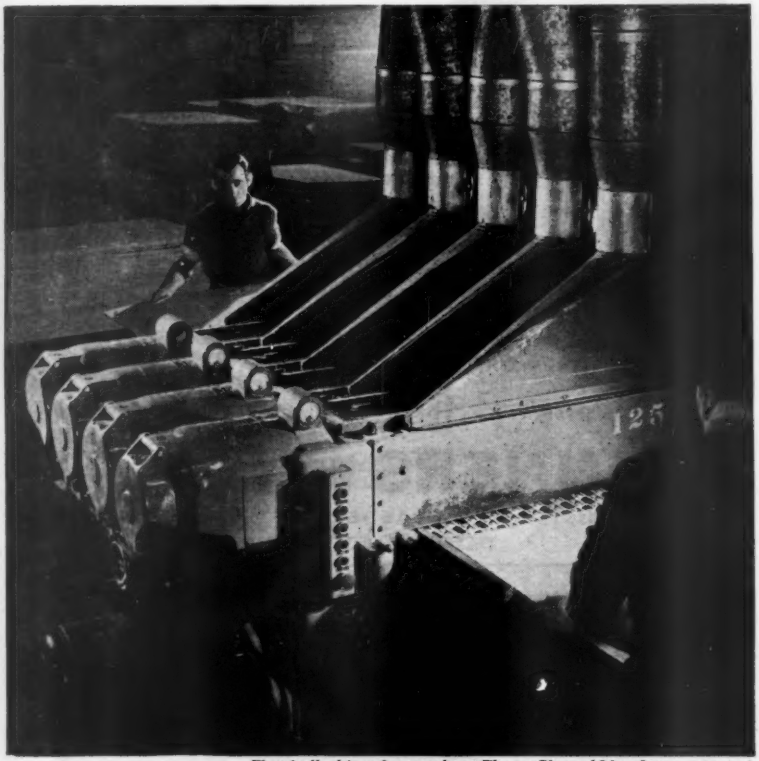

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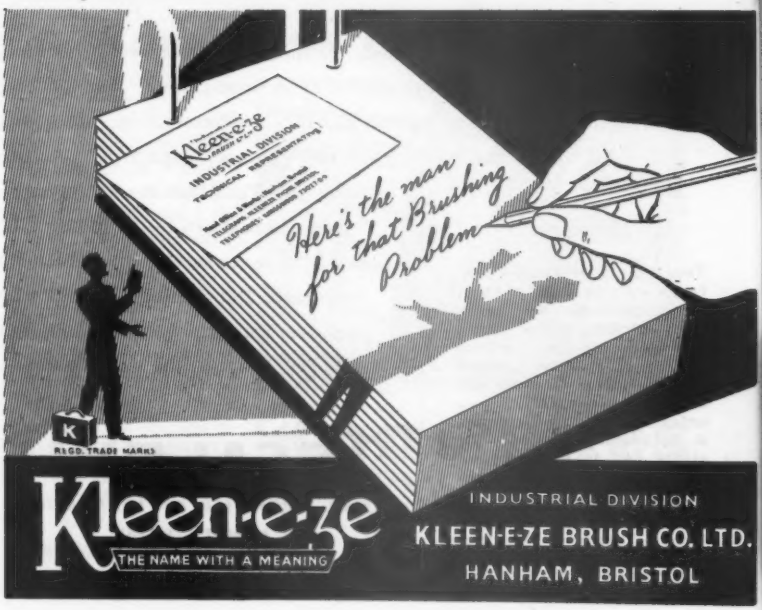
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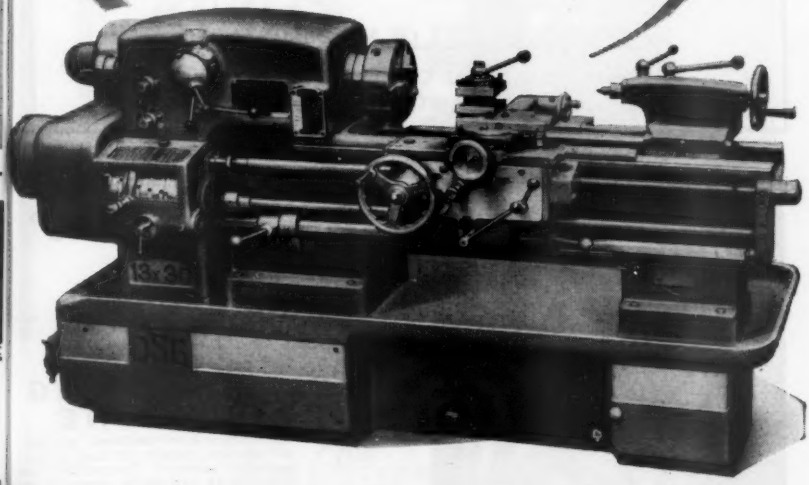

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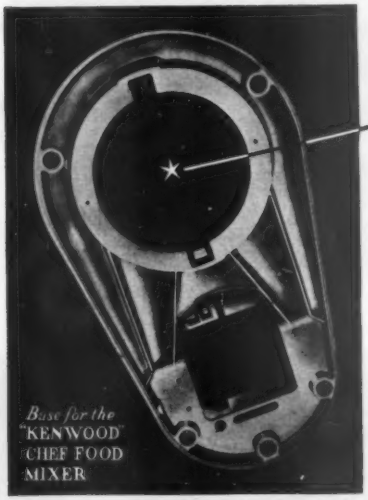

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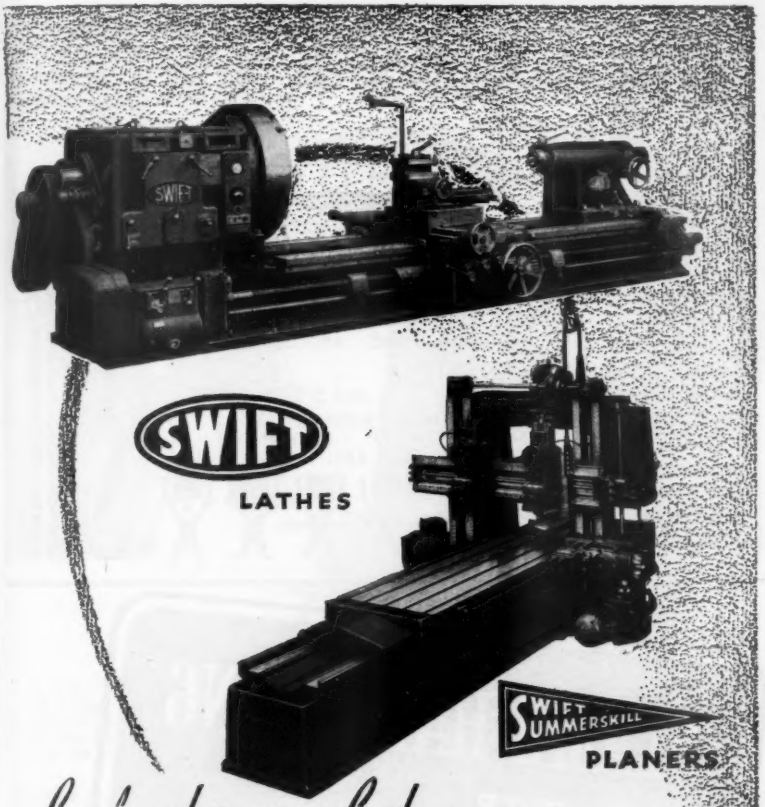

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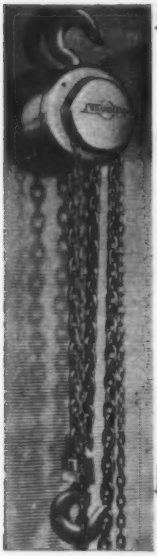

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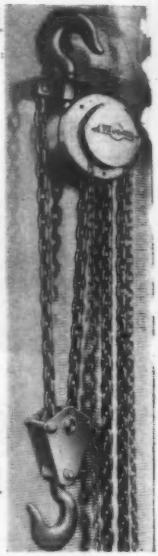

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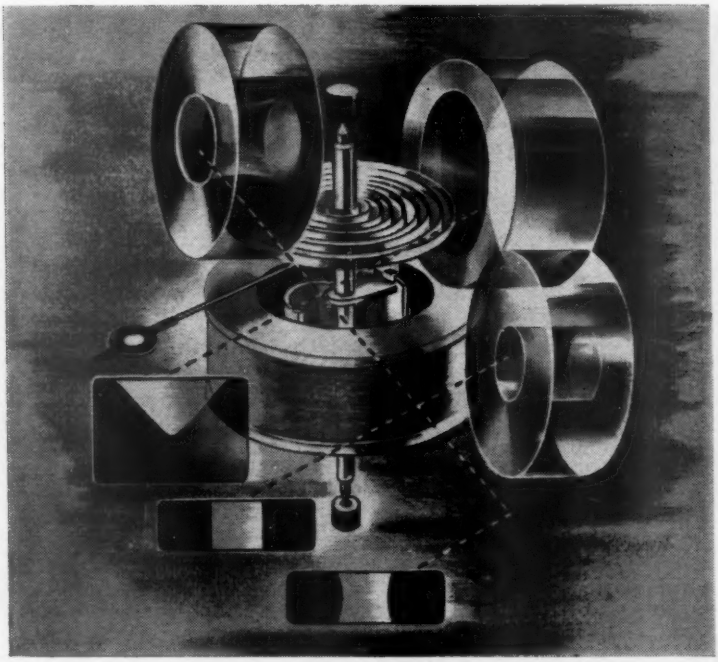

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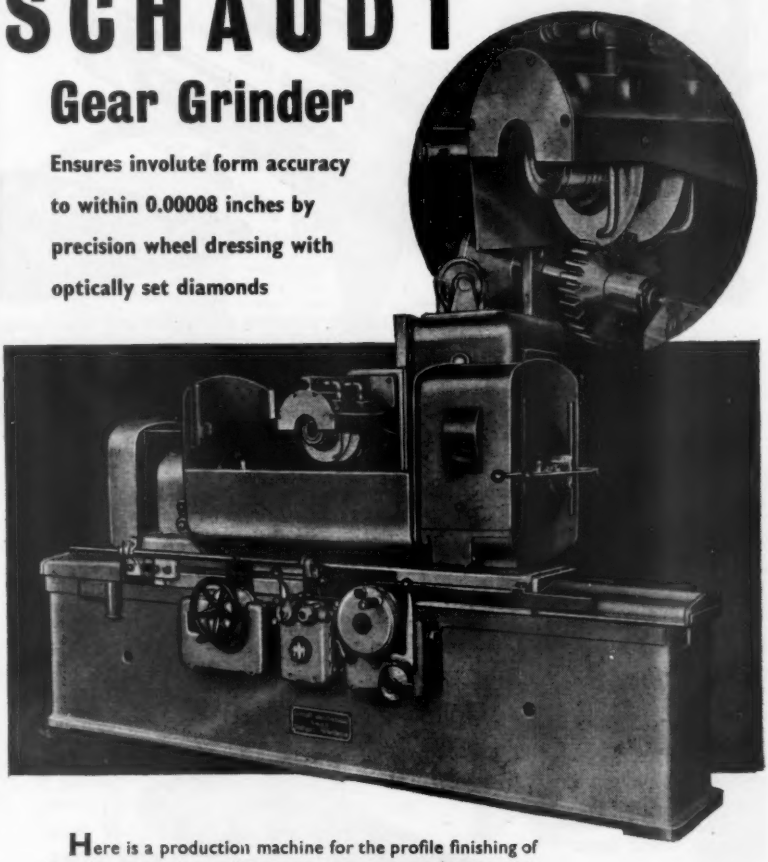

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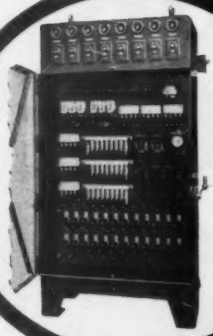

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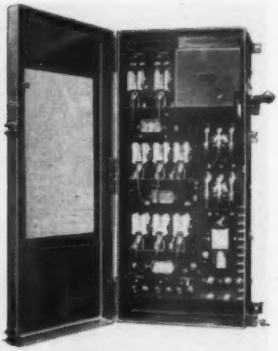

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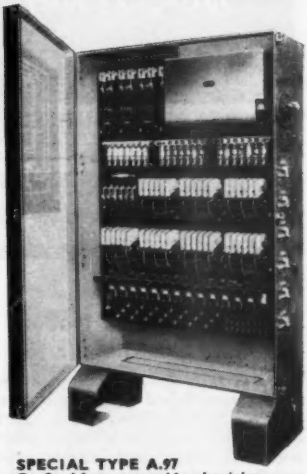

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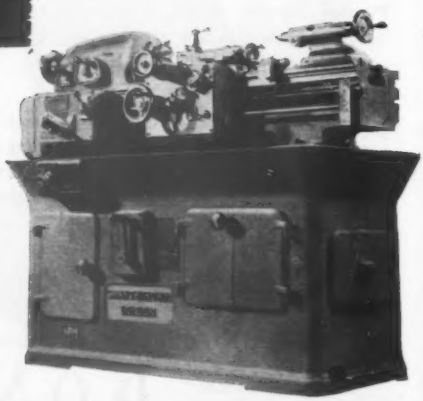

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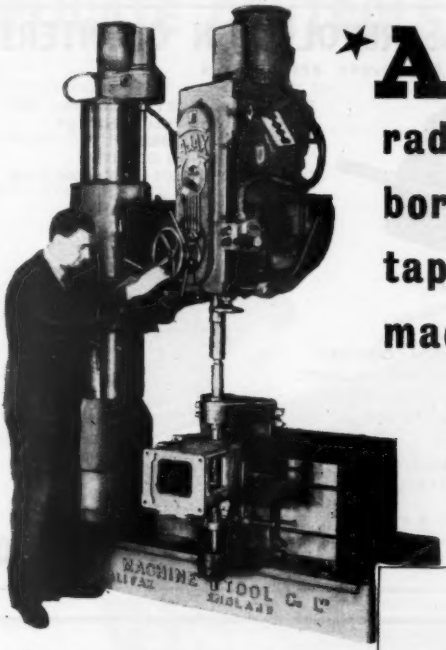

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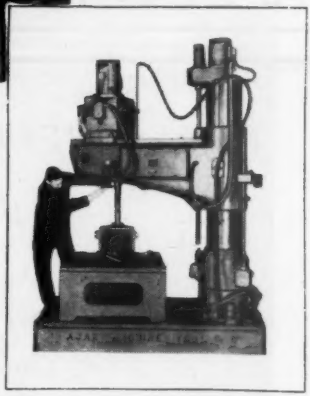

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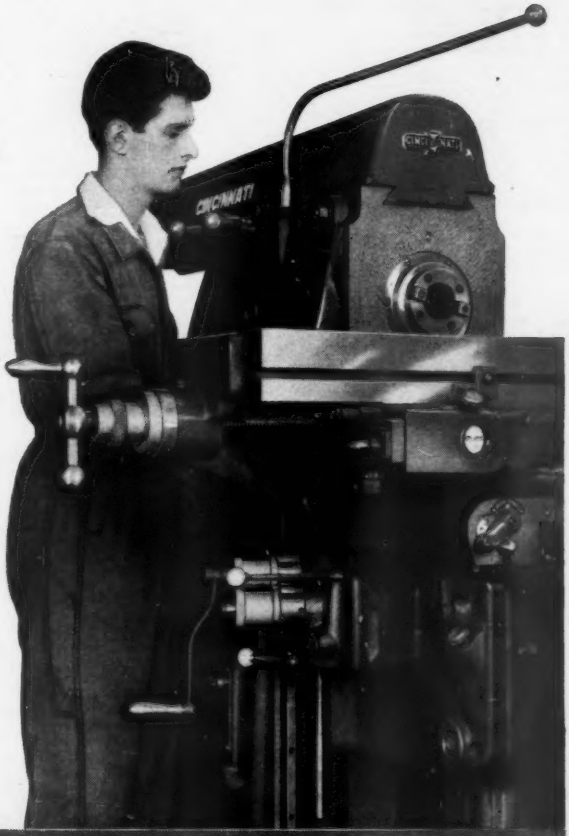

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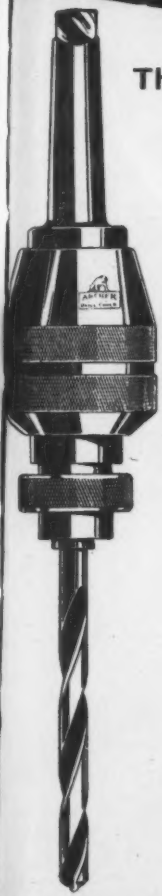

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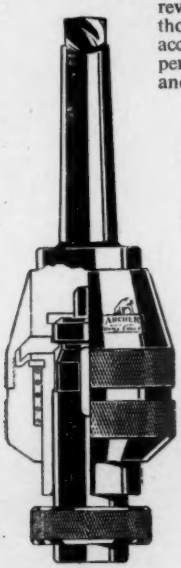

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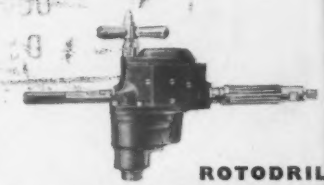

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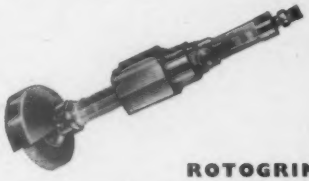

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